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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**A MODULE FOR EMPLOYING HUMAN SYSTEMS
INTEGRATION INTO THE RAPID EQUIPPING FORCE
(REF)**

by

Leon A. Higgins
and
Demetrius D. Mack

December 2006

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**A MODULE FOR EMPLOYING HUMAN SYSTEMS INTEGRATION INTO
THE RAPID EQUIPPING FORCE (REF)**

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ABSTRACT

The rapidly changing complexity of the Global War on Terrorism has changed the approach to equipping forward deployed military forces. Combatant Commanders conducting operations now require timely materiel solutions to enhance mission capabilities and reduce risk for individual Soldiers. To address this challenge the U.S. Army established the Rapid Equipping Force (REF) to assess emerging requirements, to propose solutions to those requirements, and to implement those solutions in an expedient time frame. Unfortunately, the REF lacks a consistent analytical methodology for developing alternative materiel solutions. To address the need for a Human Systems Integration analysis method, the authors developed an Assessment Based Rapid Acquisition HSI Analysis Tool (ABRAHAM) capable of generating tailored surveys and evaluating these surveys for unacceptable risks to Soldiers. To validate ABRAHAM's concept and content, ABRAHAM was showcased in three Department of Defense settings, the Human Factors Engineering Technical Advisory Group, the REF, and the United States Marine Corps' Operational Test and Evaluation Activity. The ABRAHAM appears to fill a gap in the current library of HSI tools. Based on the feedback provided during the product showcases, there is sufficient interest and technological maturity to further develop ABRAHAM to serve both the traditional and rapid acquisition processes.

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GLOSSARY OF ACRONYMS

AA	Alternates Analysis
ACAT	Acquisition Category
ADDIE	Analysis, Design, Development, Implementation, and Evaluation
AR	U.S. Army Regulation
AT	Anti-terrorism
ATEC	Army Test and Evaluation Command
AoA	Analysis of Alternates
CBRNE	Chemical, Biological, Radiological/Nuclear, Explosive
CJTF-HOA	Combined Joint Task Force Horn of Africa
COTS	Commercial Off the Shelf
DoD	Department of Defense
DoDI	Department of Defense Instruction
DoL	Department of Labor
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities
ESOH	Environment, Safety and Occupational Health
FAA	Federal Aviation Administration
FP	Force Protection
GOTS	Government Off the Shelf
HFE	Human Factors Engineering
HSI	Human System Integration

IFF	Identification Friend or Foe
KSA	Knowledge, Skills and Abilities
MANPRINT	U.S. Army Manpower Personnel and Training
MCOT&EA	Marine Corp Operational Test and Evaluation Activity
MOPP	Mission Oriented Protective Posture
MOS	Military Occupation Specialty
NASA	National Aeronautics and Space Administration
NAVSEA	Naval Sea Systems Command
NDI	Non-Developmental Item
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OSD	Office of the Secretary of Defense
PDA	Personal Digital Assistant
PE	Product Evaluation
PM	Program Manager
REF	Rapid Equipping Force
REF-FWD	Rapid Equipping Force Forward
TC-AIMS II	Transportation Coordinator's Automated Information for Movement System, Version II
TDRA	Top Down Requirements Analysis
TDY	Temporary Duty
TRAC	TRADOC Analysis Center
TRADOC	Training & Doctrine Command (US Army)

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I. INTRODUCTION

A. OVERVIEW

The rapidly changing demands and increasing complexity of the Global War on Terrorism have necessitated an improved approach for equipping forward deployed military forces. Combatant Commanders conducting operations now require rapid and functional materiel solutions to enhance mission capabilities and ultimately mitigate the risks to the individual Soldier. Previous methods for obtaining materiel solutions are limited to the capacity of the lengthy traditional acquisition process. This process requires solicitation and evaluation of proposals, documentation of contract bidding, and once a contractor is selected, intense management of the contractor to ensure compliance with all specifications of the contract. To counter this problem, the U.S. Army established an agency devoted to meeting the requirements of the Combatant Commanders. This agency, known as the Rapid Equipping Force (REF), was given three goals: a) to assess emerging requirements for materiel solutions; b) to quickly match those solutions to the emerging operational requirements of combatant commanders; and, c) to suggest solutions that can be implemented in an operationally useful time frame.

B. THE RAPID EQUIPPING FORCE (REF)

The concept of the REF first arose in a meeting between U.S. Army Colonel Bruce Jette and General John Keane in 2002. At the time, U.S. efforts were concentrated on the search for Osama Bin Laden and military intelligence directed specific attention to the caves of Afghanistan. Colonel Jette and General Keane met to discuss the various options available to efficient and effective cave searches. Previously, Army doctrine employed Soldiers to perform the tasks. From the two officers' perspectives, this method seemed to be akin to the tactics used almost four decades ago in Vietnam. The discussion led to an innovative solution that reduced manpower and significantly mitigated the risks to Soldiers. The officers developed the concept of leveraging robotic capabilities to conduct the search. Within a time, Colonel Jette acquired a remote-controlled robot

using commercial off the shelf technology (COTS) and took it to Afghanistan where it was received with good success. This incident began the evolution of the Rapid Equipping Force.

The concept of REF grew in popularity. The mission of the REF soon expanded its range of available solutions beyond robotic search drones. Rapid equipping included any solution that optimized force protection, survivability, or lethality. The REF's goal became to equip operational commanders with rapidly employable solutions of commercial off the shelf (COTS), government off the shelf (GOTS) technologies, or future force technologies that would optimize unit performance. In return, operational commanders would inform the Army leadership the extent to which the materiel solutions would allow them to keep abreast of an adaptive enemy.

Eventually, objectives of the of the REF were instantiated as: equip the force, insert COTS, GOTS, or future force technologies into the force, and assess product inserted.

The first objective, equipping the force, focuses on providing materiel solutions to the current force in order to rapidly eliminate operational capability shortfalls. The second objective, inserting technologies into the force, provides a conduit for future force technologies, threshold capabilities, or surrogates into the current operational environment for assessment by committed forces. The last objective, assessing inserted products, provides evaluations and lessons learned back to Army leadership for the purpose of refining, modifying, and streamlining Army acquisition decisions in support of the force. Together, these objectives create an automatic feedback loop to allow continual learning and development of best practices, and a strategy that supports the complexity of the Global War on Terrorism.

C. THE REF PRIORITY

As stated in the REF mission (www.ref.army.mil), the agency works directly with operational commanders to find promising materiel solutions for identified operational requirements. Consequently, one of the REF's key tasks is to frequently survey battlefield operations for possible equipment improvements. As problems or gaps are identified by forward deployed REF personnel, a request is forwarded to REF

headquarters for analysis and solution alternatives are generated. Next the Director selects a final product to field. The REF completes the process in less than 180 days, shorter than the time required in the typical acquisition cycle.

D. THE TYPICAL ACQUISITION CYCLE

In July 2004, Department of Defense (DoD) 5000 instruction was published to improve military acquisition by refining the acquisition lifecycle process (see Figure 1 below). The 5000 instruction describes a management framework that is intended to translate mission needs and requirements into systems acquisition programs. To accomplish this, the framework specifies the following five phases: Concept Refinement, Technology Development, System Development and Demonstration, Production and Deployment, and Operations and Support.

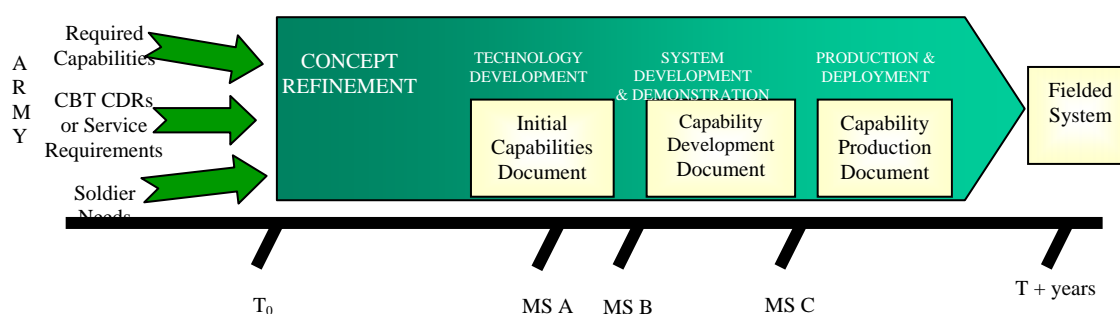


Figure 1. Acquisition Lifecycle (REF Presentation, COL Lovett, 2006)

Each phase has a distinct purpose. In the Concept Refinement phase, the initial concept is refined in order to produce a strategy for acquiring a particular system capability. At the conclusion of the Concept Refinement phase, the Defense Acquisition Board meets to determine if the project should advance to the Technology Development phase. This transition from Concept Refinement to Technology Development encompasses the Milestone A decision, which is discussed in more detail below. The Technology Development phase, focuses on providing the appropriate set of technologies to be integrated into the system. This is conducted by iteratively assessing various technologies while simultaneously refining the user requirements. In order to make a decision whether or not to proceed to the Development and Demonstration phase,

selected technologies are demonstrated in a relevant environment. This phase includes the Milestone B decision. The purpose of the System Development and Demonstration phase is to demonstrate that the system/system increment can effectively function in its target environment. Consequently, a decision is made regarding movement to Production and Deployment. This phase comprises the Milestone C.

The remaining two phases do not have Milestone decisions associated with them. In the Production and Deployment phase independent operational tests and evaluations verify the operational capability needed for satisfying mission needs. In addition, the system is implemented at all locations. During the Operations and Support phase, a program is implemented to meet operational support requirements. Efforts are focused on sustaining the system over its total lifecycle in a cost-effective manner.

According to the framework, an acquisition program may begin at Milestone A, B, or C. Progression through the program depends on whether the system meets specific criteria to continue to the next acquisition phase. Although the framework permits programs to be managed as a single project, DoD Instruction 5000.2 states that the department prefers an evolutionary acquisition strategy that delivers a mature product in increments. Under such a strategy, each increment is to begin with a Milestone B decision, and the Production and Deployment phase of each increment is to begin with a Milestone C decision. Figure 1 provides a simplified diagram of the DoD's acquisition management framework. This refined process was developed to encourage efficiency and flexibility, without minimizing creativity and innovation, when providing modern technology to the warfighter.

Despite this streamlined process, Combatant Commanders still consider it to be time-intensive, cumbersome, and generally inadequate for mission effectiveness. For instance, U.S. Army Major General Roger Nadeau, commanding officer of the Armament Research, Development, and Engineering Center (ARDEC), stated "traditional acquisition isn't working" (Onley, 2005). Timeliness of the process plays is essential. If the process produces a good result but it requires a significant amount of time, it could be inadequate for meeting mission needs.

To insure the fielding process is responsive and provides viable solutions to address prevailing mission needs, the REF seeks to place new systems within 90 to 180 days. With their focus clearly on immediately meeting the Combatant Commander's needs the REF explores existing and near-term technologies to provide solutions within the acquisition lifecycle with greater timeliness. The REF also rejected the traditional approach of solving every problem to one that meets at least 51% of the warfighters' challenges and problems. This important distinction results in an environment in which solutions are identified quickly and provided expeditiously to the warfighter. Ultimately, this acquisition approach embodies a new model that adjusts the focus such that direct involvement with the warfighting commander, engagement with Soldiers, and observations and participation in operations occur regularly. Finally, this novel approach allows modifications to be conducted on the systems as required. Together, these factors create an acquisition process that is more responsive to the needs of Combatant Commanders.

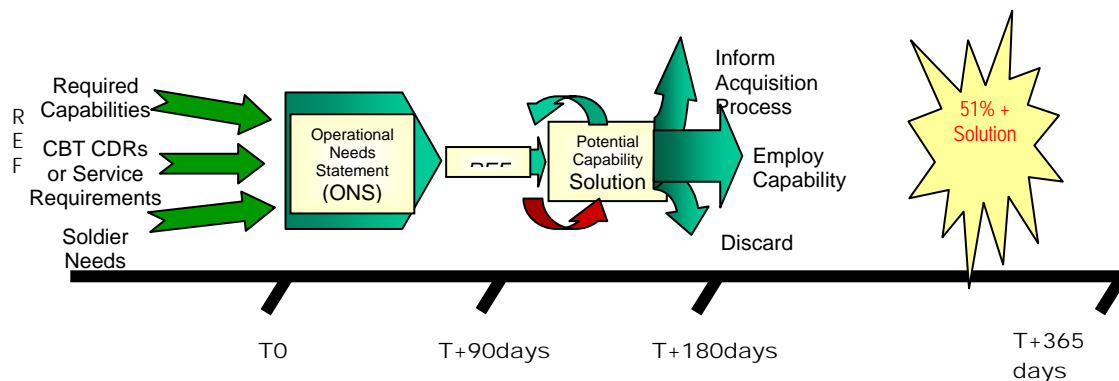


Figure 2. REF Acquisition Lifecycle (REF Presentation, COL Lovett, 2006)

Although the REF acquisition lifecycle greatly shortens the timeline for procuring new systems, there are tasks within the process that can be closely related to the traditional acquisition lifecycle. Within the first 72 hours of the REF acquisition lifecycle, analyst must determine if the request from the field is a valid requirement by comparing it to the TRADOC Capability Gap and Sub Gap List. If the request is considered a valid REF requirement then the REF analyst begins to refine the

requirement by developing an initial Concept of Operations to address the issue. The final step of the 72-hour process is a decision brief given to the REF Director to determine if the REF will pursue the project. This 72-hour process is akin to the Pre-Milestone A events including the Milestone A decision brief of the Traditional Acquisition Lifecycle.

With its focus on NDI equipment, the REF will leverage the work of equipment manufacturers in order to skip much of the work done in the Technology Development and System Integration phases immediately preceding and following the Milestone B decision brief of the Traditional Acquisition Lifecycle. The REF process resumes with limited work in what should be the System Demonstration phase of the Traditional Acquisition Lifecycle, before concluding in a fielding action that is most similar the post-Milestone C Limited Rate Production phase.

Clearly, the abbreviated REF lifecycle cannot take full advantage of many of the checks, balances, and evaluation methods of the Traditional Acquisition Lifecycle. One such evaluation method that is not explicitly included in the REF Lifecycle is analysis of how the Soldier will fully interact and perform with the new system. A rapid analysis of Human Systems Integration issues will help to ensure that a human-centered approach remains at the forefront of any decision to field new systems.

E. HUMAN SYSTEMS INTEGRATION

Human Systems Integration (HSI) is a relatively new discipline which incorporates the seven domains of manpower, personnel, training, human factors engineering, environment, safety and occupational health, soldier survivability, and habitability (Department of Defense, 2003). Although the Human Systems Integration title is new, the MANPRINT Program (upon which HSI is based) has been in existence within the U.S. Army since the early 1980's (www.manprint.army.mil/mp-history.asp)

The HSI concept began during World War II with the work of American and British engineering psychologists. The concept was refined by the United States Army, which created the Manpower and Personnel Integration (MANPRINT) management and technical program (Booher, 2003 p.xiii). MANPRINT originally consisted of six domains: Manpower, Personnel, Training, Human Factors Engineering, System Safety,

and Health Hazards. The Army added Soldier Survivability to the list of domains following fratricide incidents during Operation DESERT STORM (Kleiner and Booher, 2003 p.3). HSI advocates an approach to acquisition that places consideration of human capabilities and limitations at the forefront of decisions regarding the design, development, performance, procurement and lifecycle costs of new systems. HSI is defined as a “primarily technical and managerial concept, with specific emphasis on methods and technologies that can be utilized to apply the HSI concept to systems integration” (Kleiner and Booher, 2003).

HSI has grown from a Department of Defense centric concept to an acquisition management philosophy used by NASA, the FAA, the Department of Transportation and Defense Contractors within the United States and Canada, the Netherlands and numerous other countries worldwide (Kleiner and Booher, 2003). Other organizations have expanded the list of HSI domains to include Habitability and Medical Factors. For the purposes of this thesis, HSI consists of seven domains as defined by DoD Instruction 5000.2. These seven domains are Manpower, Personnel, Training, Human Factors Engineering, Habitability, Survivability, and Environment, Safety and Occupational Health (which generally includes Medical Factors) (Department of Defense, 2003). While these seven domains have generally existed as stovepipes in each branch of the military, the unique challenge of HSI is to coordinate the varied requirements in each of the domains into a coherent policy that maximizes total system performance. It should be noted that the integration of domains must be a robust and dynamic endeavor because the domains will not be of equal importance in every program (Office of the Assistant Secretary Research Development and Acquisition, 1998).

Historically, military systems have often ignored or minimized the attributes of the human user while maximizing perceived technological and engineering opportunities to improve overall system performance. Many personnel involved in the research, design and acquisition of military systems consider the human element of the system to be the

most adaptable. Factors related to the user were typically given a low priority. As a result, the human was forced to make unreasonable accommodations in order to make a new system work effectively.

Reports from the Washington Post and posted on Center for Army Lessons Learned indicate that the current design implementations of the \$11 billion Stryker results in unacceptable operating conditions for the crew. For instance, Soldiers are unable to attach seatbelts over their body armor and are forced to check tire pressure at least three times a day to maintain the proper pressure levels due to the weight of additional armor added to the vehicle but not accounted for in the design. Furthermore, the on board computer has a tendency to overheat and shut-down at critical moments (Smith, 2005; Zagaroli, 2005). Perhaps the most troublesome flaw of the Stryker is the vehicle's horn. The horn is not loud enough; therefore, an Army Lessons Learned report recommended Soldiers replace the horn with a local aftermarket horn once in theater. To help control traffic while in motion, Soldiers were directed to throw rocks and use hand signals, thereby exposing themselves to attack (Center for Army Lessons Learned, 2004).

In an effort to ensure that the human element receives equivalent priority in systems design and acquisition, the Department of Defense (DoD) now requires program managers to apply human systems integration techniques "to optimize total system performance, operational effectiveness, suitability, survivability, safety, and affordability" (Department of Defense, 2003). Enclosure 7 of DoD Instruction 5000.2 requires the Program Manager to develop a comprehensive HSI plan and includes overarching guidance on items to be addressed in each of the seven domains (Department of Defense, 2003). The Defense Acquisitions Guidebook (Chapter 6) serves as an excellent resource, providing further definition of the HSI domains, an overview of HSI throughout the acquisitions process, and reference for basic military instructions, handbooks, and standards relating to HSI (Department of Defense, 2004).

To this end, numerous organizations have developed guidance to facilitate the integration of requirements from the seven domains. The U.S. Naval Sea Systems Command (NAVSEA) has developed a 2-volume HSI guide for Program Managers involved in Navy ship systems (Naval Sea Systems Command, 2003). NAVSEA has

also published HSI policy for acquisition and modernization. This document delineates the various duties of organizations and establishes the idea of Program HSI Criteria, which are to be used to “assess the adequacy of design concepts from an HSI perspective” (Naval Sea Systems Command, 2005). Although geared to previous versions of the DoD 5000 series instructions, the U.S. Air Force HSI Office created both an HSI Requirement Resource Guide and an HSI Domain Checklist. These documents were developed to provide a structured walk through of the HSI domains and to facilitate in the generation of the former Mission Need Statement and Operational Requirements Document (Air Force Human Systems Integration Office, 2003; Air Force Human Systems Integration Office, 2003).

An interesting approach to HSI evaluation is suggested by Dudley-Rawley and Bishop (2002). They offer a breakdown of HSI issues into four phases: The Taxonomic Phase (HSI issue identification), the Quantitative Phase (HSI metric identification and data collection), the Empirical Phase (expert identification and analysis), and the Final Phase (database integration and report generation). Originally forwarded as an approach for extended space missions, this approach could be used to build a process by which HSI analysis and evaluations are thoroughly explored and stored as a basis for analysis of future systems.

A prevailing method of HSI evaluation appears to communicate HSI requirements in terms of the functional and mission requirements for the system to be procured. By conducting these top-down analyses, evaluators can fully understand the role of the human in the system and make informed decisions about the trade-offs between the HSI domains and other engineering or mission requirements (Malone and Miller, 2003). The HSI Plan for the Transportation Coordinator's Automated Information for Movement System, Version II (TC-AIMS II) appears to follow this approach (TC-AIMS II Project Management Office, 2003).

The evaluation methodology used to examine the HSI domain must be intuitive, and aligned with the REF's rapid acquisition philosophy. Time intensive evaluation techniques such as task analysis or requirements analysis would place a large burden on the REF analysts unfamiliar with these techniques. Because the evaluations methodology

should maximize the use of research conducted by the product manufacturer, most of the REF acquisitions will be through Non-Developmental Items (NDI). A non-developmental item is defined as any item that is available commercially or any item already developed for use by another local, state or federal government organization. Non-developmental items may require some modification prior to military use. The Army has three classifications for NDI equipment: (1) no modification required, (2) ruggedization required, (3) militarization required (Steves 1997). If properly managed, using non-developmental items can lead to lower lifecycle costs, improved reliability, and faster delivery of useful products to operational units.

DoD 5000.2 directs that when procuring NDI products, care must be taken to ensure the new system evolves with Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities (DOTMLPF) changes. DOTMLPF changes involve non-materiel solutions to capability gaps. For example a change of Doctrine, such as adding a series of 90-degree turns to the entrance of an installation can be as effective as spikes stripes or other materiel solutions when attempting to slow a vehicle. HSI domain concerns can be addressed as part of the DOTMLPF analysis early in the acquisition process, including the Functional Solutions Analysis (HSI VIRTUAL SYSCOM WORKING GROUP, 2005).

HSI practitioners are often challenged by NDI procurements because there is little ability to change system designs. Fortunately, the Defense Standardization Program has developed guidance for exploring the operational requirement, conducting market research, identifying alternatives, evaluating the alternatives, and selecting the best alternative among NDI (Defense Standardization Program, 1996).

Robust market research techniques should be employed to identify the full range of products available in commercial or other governmental environments, and an HSI analysis should identify issues, risks, and concerns that should influence the decision maker's determination of the most appropriate alternative.

F. THE INITIAL NEED

As with all new process models, opportunities exist for improvement of the tasks and the process that make up the REF acquisition lifecycle. There is a concern that each REF analyst has developed his or her own different analysis and selection techniques, because a standardized analysis methodology does not exist.

In response to this potential weakness, the REF requested that TRADOC Analysis Center (TRAC) Monterey develop a standard methodology for REF analysts. A general standardized approach to analysis should ideally consider material standards, cost benefit analysis, and Soldier usability. The requirements focused on the minimization of time required, without reducing its intuitive and flexible nature. The methodology is to be divided into two phases with time limits. Phase One must be a quick analytic process that provides initial recommendations. This analysis is to be conducted within 72 hours of the problem being submitted. Phase Two is the development of a more detailed and deliberate analysis process to refine the initial Phase One recommendations. This is conducted up to six months after the problem statement. Once the product has been fielded, Phase Three provides Soldier feedback to ensure the viability of the product.

In collaboration with TRAC Monterey, the current thesis research uses the field of Human Systems Integration (HSI) to supplement a standard methodology. TRAC-Monterey is developing an overall systems approach to support the REF. Other research supporting the TRAC Monterey effort include implementing a Rapid Ordering System, an Information Technology Management tool, and an Analysis of Alternatives Decision Support Tool.

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II. METHODOLOGY

A. GATHERING ADDITIONAL INFORMATION

The Methodology chapter describes the procedure used by the authors to gather information, refine the Initial Need Statement, and create a solution to address the REF's need. This chapter is subdivided into the following sections: Gathering Additional Information, Refining the Initial Need, Addressing the Effective Need, and Validating the Solution. In the chapters that follow, the authors present the literature reviews used as the basis for the work on this project, an instruction manual documenting the proper operation of the software solution, and a discussion of conceptual and design concerns and user feedback generated during product demonstration.

Based on the Initial Need Statement provided at the end of the Introduction, the authors traveled to the Rapid Equipping Force Headquarters in Fort Belvoir, Virginia on 18-20 July 2006 to interview REF personnel, gather additional REF process documentation, and observe REF personnel in action. During this trip, the authors interviewed Colonel Gregory Tubbs, Director, Rapid Equipping Force; Colonel Robert Lovett, REF Project Manager; Mr. John Geddes, REF Technology Management Director; Mr. Joe Rozmeski, Deputy, Operations; Mr. Scott Torgerson, Capabilities and Assessments Team Lead; and various other REF analysts working in the Operations Department. Specific feedback from these meetings is provided in the following four paragraphs.

The REF started with 12 people on 179 day temporary duty orders in 2003. In July 2006, the REF organization was manned with over 100 people, with roughly 47 people assigned to the Operations Department. Military members are now assigned for three years on Permanent Change of Station orders, and normally spend their first year in theater to gain an understanding of the conditions in the forward operating areas (J. Rozmeski, personal communication, July 18, 2006).

As of July 2006, the REF was in its seventh iteration of process refinement since January 2005. Although the common core of the organization remains, the REF has

undergone an organizational change approximately every three months. REF leadership expects this fluidity to continue for the foreseeable future (J. Rozmeski, personal communication, July 18, 2006).

The REF has operated with a focus on operations in Iraq and Afghanistan, but the REF mission is to support the entire Army. As such, the REF has established a forward detachment in Djibouti, Africa to support CJTF-HOA and stands prepared to establish similar detachments where ongoing operations require a REF presence (J. Rozmeski, personal communication, July 18, 2006). Despite the growth in manpower and sustainment of corporate knowledge (due to less frequent turnover), the REF's expanded mission requires clear operating processes and innovative analysis methods to meet the timeline established by the 180 REF Acquisition Lifecycle.

According to COL Tubbs, the REF culture is driven by delivery of products, but the organization is process adverse. To improve its process, the REF must do away with non-value added tasks. Unfortunately, there are few quantitatively oriented analysts who are skilled in quantitative techniques at the REF; the organization does not currently use quantitative tools that can provide data in support of Lean and Six Sigma process improvement initiatives (G. N. Tubbs, personal communication, July 19, 2006). For example, the System Assessment Form, (Appendix B), is too generic to accurately assess the wide range of equipment for which the REF is responsible and offers little opportunity for meaningful statistical analysis (S. Torgerson, personal communication, July 19, 2006).

B. REFINING THE INITIAL NEED STATEMENT

With this interview data and the additional process documents obtained during the trip to Fort Belvoir, the authors identified two areas in which the REF benefit from an HSI evaluation. First, inserting an HSI evaluation early in the development of materiel solutions and non-materiel solutions would ensure that REF analysts consider a human-centered approach in their alternatives analysis. Secondly, inserting an HSI evaluation into product evaluation questionnaires sent to Soldiers in the field would result in meaningful feedback that could be used to support the decision to kill or refine a system.

In order to take advantage of these opportunities, the authors developed a method to conduct these evaluations with little or no training in the HSI or MANPRINT. To gain a better understanding of the concepts to be evaluated in these REF HSI evaluations, the authors reviewed scientific and scholarly literature related to the domains of HSI. This literature review, which is included as Chapters III-IX, revealed that HSI analysis techniques used in traditional acquisitions environments are often time intensive processes requiring expert knowledge.

With a firm understanding of REF requirements and the general tasks involved in the analysis of each HSI domain, the authors refined the Initial Need Statement to create a more useful Effective Need Statement. The new Effective Need Statement follows: The REF needs to improve its analysis methodology by utilizing both qualitative and quantitative tools and methods to generate data for use in alternatives analysis, product evaluation and process improvement initiatives. REF analysts must be capable of using these tools and methods to meet time constraints imposed by the 180-day REF Acquisition Lifecycle without the need for extensive training or expert knowledge in the area of HSI.

C. ADDRESSING THE EFFECTIVE NEED

To address this Effective Need Statement, the authors developed a method of automatically generating and analyzing customized questionnaires that are tailored based on the REF analyst's description of the piece of equipment. The questions used to generate these surveys were derived from information gathered from the literature review, Army questionnaires, other domain related checklists, and Subject Matter Expert (SME) interviews. All questions included in the database were reviewed for their relevancy to REF systems; those questions that were deemed irrelevant were modified or excluded from the tool.

To display these questions in an intuitive manner, the authors created an application using Microsoft Access database software, hereafter called the Assessment Based Rapid Acquisition HSI Analysis Module (ABRAHAM). Microsoft Access is a part of the Microsoft Office Professional software package, and as such, the software is common to most military and DoD computer systems. Additionally, software developers

can utilize Microsoft Access to repackage the database in a run time environment that users can employ without installing Microsoft Access.

Programmers can take advantage of Access' limited multi-user environment to support simultaneous work by up to 255 users. Microsoft designed Access to easily integrate with other Microsoft Office products, including Microsoft Frontpage web development software. This close integration provides a straightforward method for distributing HSI questionnaires via the Internet.

ABRAHAM is designed to walk REF analysts and decision makers through the domains of HSI to determine where new products present unacceptable risks to operators, maintainers and support personnel. The goal behind development of ABRAHAM is to provide time sensitive, mission oriented subjective analysis in the absence of objective data from product manufacturers and other organizations in order to provide the best product to Soldiers in the field.

To achieve this goal, ABRAHAM uses queries to convert user input into a tailored questionnaire covering all HSI domains for use in alternatives analysis and product evaluation. ABRAHAM also provides basic analysis of responses and a written report describing areas of concern for follow-on analysis by REF analysts and contracted SMEs.

D. VALIDATING THE SOLUTION

Once the initial ABRAHAM prototype was completed, the authors used the tool to generate sample analyses on commercial and REF-related equipment to demonstrated the functionality of the tool and its reports. As deficiencies were identified, the authors made changes to the tool's design. (Conceptual and programming challenges are fully discussed in the Discussion and Conclusion Chapter.)

ABRAHAM was also demonstrated by the authors at three DoD related venues (Human Factors Engineering Technical Advisory Group (HFE-TAG), the REF, and the U.S. Marine Corps Operational Test and Evaluation Command) to validate the concept and to obtain feedback from HSI professionals and users who might use the tool in an operational setting.

Upon completion of the three demonstration sessions, the authors presented the findings TRAC-Monterey. The authors fully described the limitations of the current iteration of the tool and presented options for future work on the research. At present, ABRAHAM is one application in a suite of TRAC-Monterey applications under development for use by the REF.

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III. THE MANPOWER DOMAIN

A. MANPOWER DEFINED

Historically, the manpower domain within the Department of Defense focused solely upon the number of personnel required to complete a given mission (Department of Defense Directive 1100.4). In May 2005, the Office of the Deputy Chief of Staff G1 provided additional guidance with respect to whom the definition applies and upon areas which it focuses. The MANPRINT Handbook (2005) expands the breadth of the manpower domain including both military and civilian. Furthermore, the G1 acknowledged the limited nature of defining manpower as only concerning the completion of mission. In response the G1 proposed that manpower should be defined as the total manning throughout the system's operational lifecycle to include the maintainability, sustainability, and training necessary for the system to perform optimally.

B. MANPOWER DOMAIN IN HSI

Within the field of HSI, the manpower domain has encompassed the comprehensive definition proposed by the MANPRINT Handbook (2005) (Booher, 2003). HSI practitioners are primarily concerned with the interaction of manpower within the context of the other six domains. However, this concern is not only limited to the interaction among the other six domains but also includes the effects of manpower across the entire lifecycle of the system. The HSI practitioner's primary goal is to ensure optimization by having the right number of people in the right places throughout the system. To achieve this goal, HSI practitioners utilize tools such as manpower estimates and workload analyses to provide alternatives that address a given unit's capabilities and available resources. These analyses are particularly important for the REF, which typically imports new or modified systems into existing circumstances.

C. HSI, MANPOWER, AND THE REF

At present, a unit requests materiel solutions from the REF in order to improve performance or address an identified gap. As a result, the REF analyzes potential alternatives for the unit to implement or incorporate into its mission. However, the

materiel solutions provided are not necessarily tailored to the unit's available manning resources and capabilities. For instance, the unit's current levels of manpower are not properly considered within the REF analysis or the materiel solutions provided. The specific value-added of the HSI approach within the manpower domain is found in the systemic analyses regarding the trade-offs between current levels of manpower and required levels of manpower necessary when a particular system is fielded. The HSI approach to manpower supplements existing methodologies by ensuring that fielded solutions will be optimal with current manpower levels.

1. Goal of an HSI Manpower Evaluation

The ultimate goal of any HSI evaluation is to ensure that the target audience's capabilities and limitations are fully in the design rather than as elements that can adapt to the system once it is developed (Malone and Miller, 2003). A manpower analysis is conducted as part of the HSI evaluation for a traditional acquisition project to determine the most cost effective mix of Soldier, civilian and contractor support necessary to operate, maintain, support, and provide training for the system in accordance with Section 2434 of Title 10, U. S. Code (Department of Defense, 2004). The manpower determination can have great influence on safety, design, training and overall system cost.

Manpower requirements for maintenance and support are typically workload driven while manpower requirements for operators are more frequently determined by doctrine (Office of the Deputy Chief of Staff G1, 2005). Manpower studies should be conducted to ensure: (1) design options that reduce workload and increase program affordability are given top priority; (2) total ownership costs are minimized; and, (3) future resources are preserved for more efficient use in other ACAT programs (Malone and Miller, 2003). Among other factors, the manpower study should include an analysis of job tasks, operation/maintenance rates, associated workload, and operational conditions to optimize the types and number of people required (Department of Defense, 2004).

2. Manpower Evaluation in a Traditional Acquisition Setting

Most manpower analyses should begin with a Top Down Requirements Analysis (TDRA) to identify each of the relevant functions of the system and which functions of the system should be automated, eliminated, consolidated or simplified (Malone and Miller, 2003). For a given operational condition, the TDRA and the functional and task analyses should provide measures of peak workload, which are usually stated in the form of average man-hours of work per unit time. This workload data is compared to a workload standard, such as a 40 hour work week, to determine the number of individual billets required for the system (Malone and Miller, 2003).

This basic manpower computation must be augmented with other factors that affect Soldiers as they do their jobs. For example, environmental conditions, fatigue, or cognitive, physical or sensory overload in the target audience may require additional manpower to achieve a desired level of performance. The analyst must also add billets directed by law or other authority, which must be provided regardless of the calculated workload. These “Directed Billets” may be required to provide a specific knowledge, skill, ability or qualification not normally found in the target population (Malone and Miller, 2003).

Finally, the manpower analysis must look beyond the system as an individual item and explore the effects the system has from a system-of-systems or family-of-systems perspective. While this additional examination may identify commonalities or duplication between multiple systems, it will also allow the analyst to examine the distribution of workload among available personnel. It may be determined that, while the individual system does not create cognitive, physical or sensory overload, the individual system in concert with other systems may create a situation where more billets are required.

The manpower analyst must be keenly aware that an assigned role for human performance may vary with changes in operational conditions. After the minimum billet requirements are calculated, the manpower analyst must then examine other operational conditions and scenarios to ensure this minimum billet computation is capable of

satisfying the manning requirements, to include how the manpower requirements will impact training systems and legacy technologies found in the unit (Malone and Miller, 2003).

Once the manpower functions and requirements are fully understood, the manpower analyst can work with other members of the design team to determine where selected human tasks may be allocated to automation technologies. After allocating these functions to either a human or automation and breaking each of these functions into its component tasks, the analyst can then determine the appropriate roles for the humans in the system (Naval Sea Systems Command, 2003; Department of Defense, 2004).

Automating of tasks is enticing because it promises reduction in manpower requirements and human error, and enhancement of situational awareness. Used in controlled circumstances, automation can limit increases manpower requirements for new systems. Unfortunately, automation is not the magic wand that solves all manpower issues because even for an automated function or task, the human must still serve as supervisors, monitor, decision maker, system integrator, or backup performer (Malone and Miller, 2003).

While automation often reduces physical workload, cognitive workload often increases. Operational experience and empirical research has also shown that automation does not reduce the overall amount of errors, but instead has introduced new and different kinds of error. Using automation to enhance situational awareness though not necessarily a viable solution because the technology often provides only information and data. The technology still requires the human to commit cognitive resources to synthesize the information and data into knowledge of the tactical situation (Kleiner and Booher, 2003; Malone and Miller, 2003).

Given the limitations of automation, technologies that can reduce the numbers of humans required for operation, maintenance and support of the system are critical. This is due to military manpower requirement being defined as a zero-sum environment due to statutory constraints on military end strength. This concept is critical because it requires the Program Manager and Army stakeholders to make trade-offs between systems in order to maintain force levels. If a new system will require more manpower than its

predecessor then another system must be identified as the bill payer for the new system. For example, if a new weapons system requires more Fire Support Specialists Military Occupation Specialty 13F (MOS 13F) than the Army inventory can support then Army decision makers must determine which MOS will lose manning to fill the gap (Kleiner and Booher, 2003; Malone and Miller, 2003).

In summary, the HSI domain of Manpower is concerned with determining the optimum mix of military, civilian and contractor personnel and where possible, reducing the number of people required to safely and efficiently operate, maintain and support a system. To achieve this mix and define the manning reduction concept for the system, the manpower analyst will normally conduct a TDRA to identify the roles of the human in the system, assign critical functions and tasks to these roles, and examine the expected performance of the system through modeling and simulation of the various operational conditions and scenarios in which the system will be employed.

3. Specific Objectives of a Traditional HSI Manpower Evaluation

- Define the proper mix of military, civilian, and contractor support required to efficiently accomplish projected missions (Malone and Miller, 2003).
- Document system manpower requirements and method of requirement determination for use in tradeoff analysis (Malone and Miller, 2003).
- Eliminate high frequency, labor intensive tasks requiring multiple people or system designs that increase manpower requirements over those of the predecessor systems (Air Force Human Systems Integration Office, 2003).
- Optimize the total manpower requirements by leveraging technologies designed to decrease workload (Naval Sea Systems Command, 2005).
- Identify mission tasks, operational conditions and performance standards assigned to humans in the system (Air Force Human Systems Integration Office, 2003).
- Identify environmental factors and operational conditions that may require additional manpower to maintain acceptable levels of performance (Department of Defense, 2004).
- Identify constraints of predecessor systems that impact manpower in the new system (Naval Sea Systems Command, 2005).
- Determine the frequency, criticality, and cognitive, physical, and sensory demands of mission functions and tasks to identify possible human/system overload situations (HSI VIRTUAL SYSCOM WORKING GROUP, 2005).

- Recommend process improvements and design options to minimize workload-intensive tasks and manpower levels required to effectively operate, maintain and support the system (Malone and Miller, 2003).
- Identify policies or other issues that impact attainment of manpower objectives or the Program Manager's ability to successfully meet acquisitions Milestones (Malone and Miller, 2003).
- Develop policies to provide for career progression, assignment rotation, and combat augmentation of military, civilian and contractor personnel assigned to the system (Air Force Human Systems Integration Office, 2003).
- Validate the system's manpower quantity and quality requirements after completion of system and equipment installations (Department of Defense, 2003).

4. A Practical Manpower Evaluation for REF Systems

Given the number of systems that REF analysts examine and the time constraints placed on these examinations, a full TDRA is not practical. The REF analyst must be able to quickly identify the manpower implications of a new system or technology and make decisions concerning the feasibility of its implementation. Because most of the REF products are NDI/COTS/GOTS, the REF analyst does not have the ability to influence the product's design to increase automation or otherwise introduce engineering solutions to reduce manpower requirements.

The REF analyst must focus on a sound assessment of whether the new system will require a higher, lower or equal number of personnel as the current technology or doctrinal solution demands and whether the new system will change the ranks, grades or specialties of the target audience. To make these determinations, the emphasis for NDI projects must be on problems in the existing system/doctrine, requirements generated from basic functional/task analyses, requirements for reduced manning, and any anecdotal, parametric, or subject matter expert data on workload/ workload distribution from previous or similar systems (Malone and Miller, 2003).

If the REF analyst determines that sufficient end-strength is not available, then the analyst should be prepared to make MOS/system trade recommendations to the Program Manager if the system is put forth as a new program of record which could potentially be fielded to the entire Army.

Suggested questions are provided to support the manpower determination for the REF analyst. Specific metrics for additional REF manpower studies would include: time on task, average workload, or number of personnel. This discussion of the Manpower domain suggests several questions that the REF analyst could pose to evaluate a proposed system (refer to the Manpower portion of appendix A for questions).

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IV. THE PERSONNEL DOMAIN

A. PERSONNEL DEFINED

In its most simplified form, the term personnel refers to “the people used to fill manpower positions” (Mobilization Handbook, 1986). Manpower positions encompass both military and civilian positions. Policies governing DoD military personnel are set forth in U.S. Code Title 10, subtitle 1 General Military Law, part II Personnel (U.S. Code Title 10). In particular, Title 10 addresses recruitment and retention and outlines the minimum standards for qualified applicants as well as the progression of the members through their individual services. For the U.S. Army, these policies are further defined by the policies of the U.S. Army Human Resources Command.

B. PERSONNEL DOMAIN IN HSI

For the HSI practitioner, DoD personnel are the critical elements, which are the common link to all systems. The Personnel domain of HSI focuses on the relationship between a member’s knowledge, skills and abilities (KSAs) and the required KSAs for the particular job in which they are assigned to perform (Booher, 2003, p. 387). The Personnel domain in HSI attempts to ensure that all personnel (i.e., operators, maintainer, and supporter) are properly employed in the appropriate positions throughout their service. Accordingly, the HSI practitioner ensures that all “personnel requirements should be established consistent with the aptitudes and skills of the user population that is expected to be in place at the time the system is fielded and over the life of the program” (Coast Guard Manual, 1994).

The HSI Personnel domain also requires two essential pieces of documentation (Booher, 2003). The first delineates the appropriate KSAs required to properly operate the new system. This step is important due to its potential predictive ability ultimately eliminate certain user populations. If inappropriate KSAs are considered, practitioners may unknowingly and unnecessarily limit the pool of qualified candidates. The second piece of documentation is the accurate Soldier personnel folders, which list previous training and qualifications of potential users. Ensuring that all personnel folders are up-

to-date minimizes potential waste of resources, such as training unqualified Soldiers who do not possess the required cognitive capabilities.

C. HSI, PERSONNEL, AND THE REF

Consistent with the Manpower domain, the REF is presented with the challenge of matching the system's personnel requirements to the available resources within the field in which the system will be implemented. In other words, the personnel pool from which qualified individuals are chosen to interact with the system is already limited. Therefore, when addressing the necessary personnel for system implementation, the REF analyst does not have the option to alter the existing personnel structure. This approach differs from the traditional acquisition methods that centralized the system (i.e., implementing minimal modifications to the system) and more often worked to manipulate other variables to complement the overall circumstance.

Due to the REF's inability to change personnel requirements in deployed units, the primary concern of the REF analyst is to ensure the most optimal match between the system's requirements and the KSAs of readily available personnel. Essentially, the REF must assess what is currently available in the field and estimate their ability to adapt levels as it relates to the system's KSA requirements. If a system requires KSAs that are beyond or vastly different than the competency levels of the available personnel, another solution must be sought. Without assurance that the product being fielded matches the KSA's of the available personnel, the system will not reach optimal levels of performance. System optimization requires personnel (i.e., operators, maintainers, and supporters) that understand the system.

1. Goals of an HSI Personnel Evaluation

Where a Manpower evaluation is concerned with the number and quality of billets required to accomplish the mission, a Personnel evaluation should examine the people who will fill those billets to determine if they possess the knowledge, skills, abilities, aptitudes and experience required to successfully interact with the system (Department of Defense, 2004). The Personnel evaluation should not only be concerned with the current military population but should also project into the future to determine how changes in the population will affect system performance (Air Force Human Systems Integration

Office, 2003). The Personnel domain is directly related to recruiting, retention, training system development, and system design.

The Personnel evaluation should build on the Manpower evaluation that includes an analysis of job tasks, operation/maintenance rates, associated workload, and operational conditions to optimize the types and number of people required (Department of Defense, 2004). The ultimate goal of the Personnel evaluation is to ensure that the new system does not require cognitive, physical or sensory skills that the military population cannot support. Fielding a system that requires a skill or ability that is not in the current military population should be considered a critical or major risk to readiness, personnel tempo, and system funding requirements (Office of the Deputy Chief of Staff G1, 2005).

2. Personnel Evaluation in a Traditional Acquisition Setting

As stated above, the Personnel evaluation builds on the Manpower estimate and is based on the system description, anticipated skill requirements based on job tasks and operational conditions, recruiting and retention trends, and projected characteristics of target occupational specialties. In conjunction with the Manpower estimate, a Target Audience Description (TAD) is developed to identify the population that will train, operate, maintain, and support the new system. Much like the manpower estimate, the TAD is reconsidered and revised throughout the acquisition process (Naval Sea Systems Command 2005; Office of the Deputy Chief of Staff G1, 2005).

The TAD should include the following information about the military, civilian, and contractor force structure: military operational specialty (MOS)/series/additional skill indicators (ASI) descriptions; physical profile (PULHES) requirements; security clearance requirements; biographical information; anthropometric data; and aptitude descriptions as measured by the Armed Forces Vocational Aptitude Battery (ASVAB) (Department of Defense, 2004). The TAD should also address consideration for combining, modifying or establishing new MOS and ASI codes (Department of Defense, 2004; Office of the Deputy Chief of Staff G1, 2005).

Personnel capabilities are normally stated in terms of knowledge, skills, abilities (KSAs) and are usually measured by the percentage of the population that meets the

requirement. There are two well established measures of personnel factors that can be useful in defining or classifying the population: ASVAB and PULHES measures.

The ASVAB is a Department of Defense multiple aptitude test used for selection and classification. It has been validated for training (Earles and Ree, 1992) and job performance (Ree and Earles, 1994). The ASVAB consists of verbal and quantitative tests, two speed tests and technical knowledge tests. The verbal and quantitative tests are Word Knowledge (WK), Paragraph Comprehension (PC), Arithmetic Reasoning (AR), and Mathematics Knowledge (MK). Numerical Operations (NO) and Coding Speed (CS) are the two speed tests. The technical knowledge tests are Electronics Information (EI), Mechanical Comprehension (MC), Auto and Shop Information (A/S), and General Science (GS) (Powers, 2005).

The primary composite score computed from the ASVAB for use by the Services is the Armed Forces Qualification Test (AFQT). The AFQT score is determined from four areas of the ASVAB: Word Knowledge (WK), Paragraph Comprehension (PC), Arithmetic Reasoning (AR), and Mathematics Knowledge (MK). The formula to derive the AFQT “raw Score” is $2VE + AR + MK$, where VE (Verbal Expression) is a scaled sum of WK and PC.

The AFQT “raw score,” is then converted into a percentile score. For enlistment purposes, AFQT scores are divided into the following categories: Category 1 falls between the 93rd-100th percentile, Category 2 falls between the 65th-92nd percentile, Category 3A falls between the 50th-64th percentile, Category 3B falls between the 31st-49th percentile, Category 4A falls between the 21st-30th percentile, Category 4B falls between the 16th-20th percentile, and Category 4C falls between the 10th-15th percentile. Category 5 applicants fall below the 10th percentile. Federal law mandates that nobody below the 10th percentile is eligible for selection and only 20% of applicants below the 30th percentile are eligible for service selection (Powers, 2005).

The PULHES is a six factor profile system used to set physical standards for entry into an MOS. According to Department of the Army Pamphlet 611-21, “PULHES identifies the broad physical demands of an MOS and the physical ability required of an individual to perform the duties required by the MOS. The physical profile serials

associated with an individual MOS provide a more precise means of matching individuals to positions” (Department of the Army, 1999). The PULHES acronym is defined as follows:

P—Physical capacity or stamina.

U—Upper extremities.

L—Lower extremities.

H—Hearing and ear.

E—Eyes.

S—Psychiatric.

3. Specific Objectives of an HSI Personnel Evaluation

- Define the population of military, civilians and contractors including human performance characteristics based on the system description, operation/maintenance rates, associated workload, and operational conditions (Kleiner and Booher, 2003).
- Identify Personnel high drivers issues, to include:
 - “personnel screening requirements” (physical or mental).
 - “difficult jobs that increase aptitude or educational background requirements”
 - “qualitative requirements that are not in abundance in the current and projected recruiting pool” (Air Force Human Systems Integration Office, 2003).
- Determine if special physical requirements exist which may limit the population available to operate, maintain, and support the system (Malone and Miller, 2003).
- Determine if special cognitive requirements exist which may limit the population available to operate, maintain, and support the system (Malone and Miller, 2003).
- Determine if special sensory requirements exist which may limit the population available to operate, maintain, and support the system (Malone and Miller, 2003).
- Review current personnel policy and recruitment trends to better define the human performance characteristics of the users (Department of Defense, 2004).
- Determine if the new system will lead to a combination, modification, or establishment of new military occupational specialties or additional skill indicators (Malone and Miller, 2003).
- Verify that personnel availability, recruiting issues, and anticipated skill identifiers will not degrade system operation, maintenance or support (Department of Defense, 2004).

- Verify that the personnel requirements determination addresses additional requirements imposed by watchstanding or duty cycle rotation (Malone and Miller, 2003)
- Determine the implications of reduced staffing on system performance (Malone and Miller, 2003).
- Explore technology implementations to reduce personnel requirements throughout the program lifecycle (Naval Sea Systems Command, 2005).
- Address specific factors that may affect personnel requirements, such as surge combat requirements and expected duration of the conflict (Department of Defense, 2004).

4. A Practical Personnel Evaluation for REF Systems

Because the REF is sending COTS/GOTS/NDI systems to preexisting units in the field, manipulating knowledge, skills and abilities is not an option. The REF analyst must focus on the technology and compare the requirements for operation, maintenance, and support of the equipment with the minimum standard allowed for an Army unit of the type that will receive the equipment. The goal of this analysis should be to ensure that any equipment sent forward from the REF will not overwhelm the Soldiers in the field.

To make this determination, the REF analyst should compare the new technology to any existing system/technology to determine the new requirements imposed by the REF intervention. If there is no existing system in place to base an anecdotal or parametric estimate, a subject matter expert (SME) opinion could be used to determine if there are cognitive, physical, or sensory skill requirements beyond those found in the specified user population.

The REF analyst may be able to generalize ASVAB and PULHES scores to classify the population so that reasonable inferences can be made. For example, if a REF system is estimated to require a CAT 1 AFQT score and PULHES line score of 111111 then the REF analyst can use this information to determine that there may be significant difficulty in finding people to meet this personnel requirement. Conversely, if a CAT 3 AFQT score and PULHES line score of at least 111221 is required then it may be easier to meet these personnel requirements.

At the end of REF product evaluation, the REF analyst should be able to make recommendations to the Program Manager for initial Personnel determinations, including MOS/system trade recommendations if necessary. The questions provided in the Personnel section of appendix A will assist in the personnel determination for the REF analyst.

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V. THE TRAINING DOMAIN

A. TRAINING DEFINED

The Department of Defense Directive (DoDD) 1322.18 dated September 3 2004 specifically defines training as the “instruction and applied exercises for acquiring and retaining the knowledge, skills, and abilities (KSA's) required to complete specific tasks” (Department of Defense, 2004). This directive focuses on the methodology that leads to the outcome - performing tasks. A few years later, the Army expanded on the Department of Defense's (DoD) definition to further emphasize both the interaction of the person with some environmental variable and the overall purpose of the tasks. The revised Army Field Manual (FM) 7-0 (2002) defines training as the “process that melds human and material resources into credible, demonstrable capability to mobilize, deploy, fight, sustain, and win any conflict.” (Department of the Army FM 7-0, 2002) The ultimate goal of winning conflicts provides a context in which the tasks are being performed. The specificity facilitates a common understanding about what the training should facilitate among all personnel from the training developer to the participants who are the consumers of the training.

Within the field of Human Systems Integration (HSI), more precision was applied to the DoD and Army definitions, which led to a more comprehensive understanding of the field manual's general approach. Booher (2003), crafted a definition that further described the need to not only acquire and retain the necessary KSAs, but also transfer the acquired KSAs to a variety of environments such that it transfers into the desired performance (i.e., safe and effective). Furthermore, Booher expanded on training methodology to include technology and addressed the need to consider varying skill levels as they relate to the requirements of the task. As such, the HSI field has collectively defined training as “...promoting the safe and effective performance of socio-technical systems by facilitating the acquisition, retention, and transfer of user knowledge, skills, and abilities through the design of effective curricula and training technologies and through influencing system design, development, test and development

in such a way as to effectively integrate knowledge about requisite user skills, abilities and performance requirements throughout all phases of the system lifecycle” (Archer, Headley, and Allender, 2003, p. 440).

B. TRAINING DOMAIN IN HSI

Within the field of HSI, training is one of 8 domains. The training domain addresses training at two levels: strategic and tactical. The strategic approach underscores the importance of reflecting on the role of training throughout the entire existence of the system – “from cradle to grave” – in which tasks are performed. As such, training developers need to ensure an appropriate training plan has been designed, disseminated and continually evaluated throughout the entire lifecycle of the system (Booher, 2003, 440). This comprehensive approach addresses the needs and requirements that may vary throughout the system and, more importantly, highlights the importance of providing the combination of KSAs needed so that personnel are equipped to effectively operate maintain, and support the system over time (Booher, 2003, 393).

On the other hand, the tactical goal of training in HSI is to develop effective and efficient training instruction that promotes transfer of learning from the instructional setting to the job. HSI’s unique contribution to the training area is the consideration of training transfer. HSI recognizes that the overall effectiveness of training is demonstrated not only in learning and retaining the content, but also applying or transferring it into effective, desired performance. Previous studies REF have demonstrated that the environment in which one learns or trains has a significant impact on performance, especially when it is distinctly different than the target work environment. In general, the more similar the training environment to the work environment, the more likely personnel will transfer their new KSAs to the task at hand. This is an important consideration since the ultimate purpose of training is to positively affect performance on the job such that it leads to optimally effective and efficient outcomes. Traditionally, researchers and practitioners in the training domain have not focused on this aspect – likely due to the ease with which the line between the training plan and training delivery can be blurred (Booher, 2003, 393). In essence, the training

domain of HSI specifically addresses the training requirements for the overall system and refocuses our attention on the most important outcomes of training-performance on the job.

C. HSI, TRAINING AND THE REF

Historically, decision makers typically focused on the gaps between current and desired training outcomes. This analysis generally involve evaluating the capacity of current training initiatives and conducting a training needs assessment of the new systems. The gap is then calculated as the difference between the needs of the new system and the needs met via current training efforts (Booher, 2003, 393). Training needs assessment or analyses were typically done by using models such as the ADDIE Instructional Systems Design model.

ADDIE is an instructional systems design (ISD) model consisting of a five-phased approach and includes the following stages: the Analyze, Design, Develop, Implement, and Evaluate. In the Analyze phase, the instructional problem is clarified, the need and objectives are identified and established. The Design phase is where the instructional approach will be developed. This phased is also where the media choices are made. In the Develop phase, subject matter experts (SMEs) and program developers produce learning material. The Implement phase consists of putting into action the content developed within the other phases. The final stage is the Evaluation phase. This consists of an impartial evaluation of all material and aids. This evaluation identifies material that should be revised.

Due to time the limitations in which that the REF operates, such models are not the best method of analysis. Constraints on time can result in a reduction in the breadth or depth of the approach. The REF requires an approach as compressive as the ADDIE but not as time-intensive. HSI provides such an approach within its training domain. Additional HSI issues encountered by the REF are:

- Identifying and balancing the training tradeoffs with other HSI domains.
- Developing appropriate methods for training implementation, addressing the question of embedded versus formal training.
- Predicting training effectiveness.
- Establishing training performance metrics.

With increasing pressure to constrain budgets, the DoD has stressed the evaluation of training efforts or initiatives with respect to how well the training resulted in the desired outcomes. Such evaluative efforts not only allow the DoD to understand current effectiveness of training efforts but also to track the efficacy of training initiatives. Therefore, the DoD placed more emphasis on the link between training and performance. As a result, preliminary training transformation performance assessment metrics were established (GAO, 2005). The development of training performance metrics ensures that learners achieve the criteria or standards necessary for proper task performance (GAO, 2005). Training effects are measured by calculating how much performance on a given task improved as a result of participating in training. This calculation is referred to as training transfer. Training efficacy is denoted by high training transfer scores.

Previously proposed models for training have generally corresponded to the method in which training was implemented. The narrow approach of these models manifest into limitation, particularly for decision makers; thus, HSI has developed two models to guide the strategic and tactical implementation of training. The training domain, especially with respect to the system acquisition model, encompasses the requirement design, testing, and deployment of the training (see Figure 3). This approach is used at the strategic level to implement training across the lifecycle of the system. The Analysis, Design, Development, Implementation and Evaluation (ADDIE) model, demonstrated in Figure 4, is used at the tactical level of HSI for design and implementation of training methods.

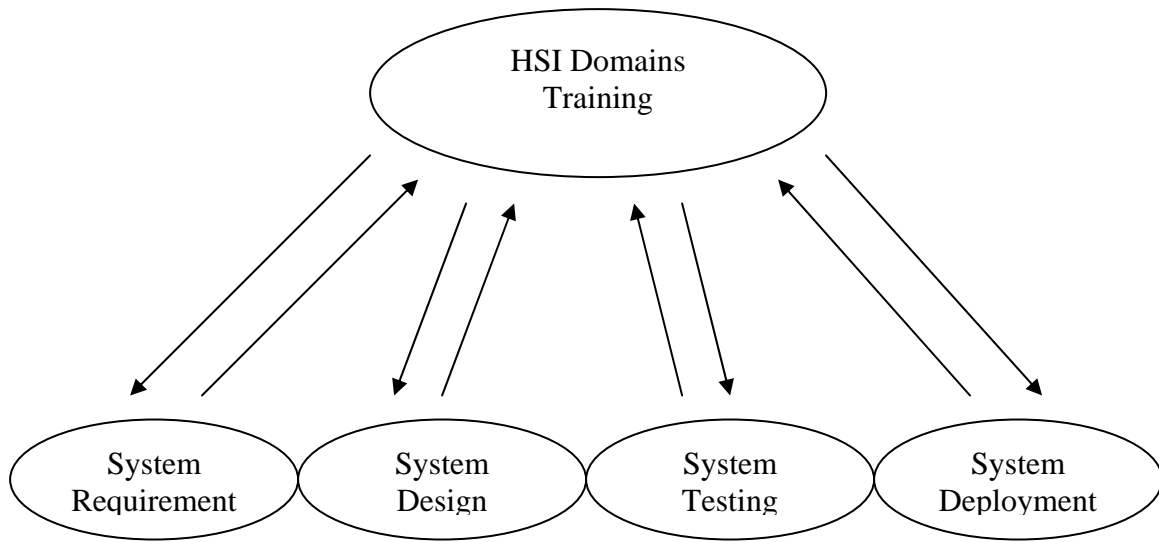


Figure 3. Schematic diagram representing flow of training expertise in HSI approach (Hettinger, 2003).

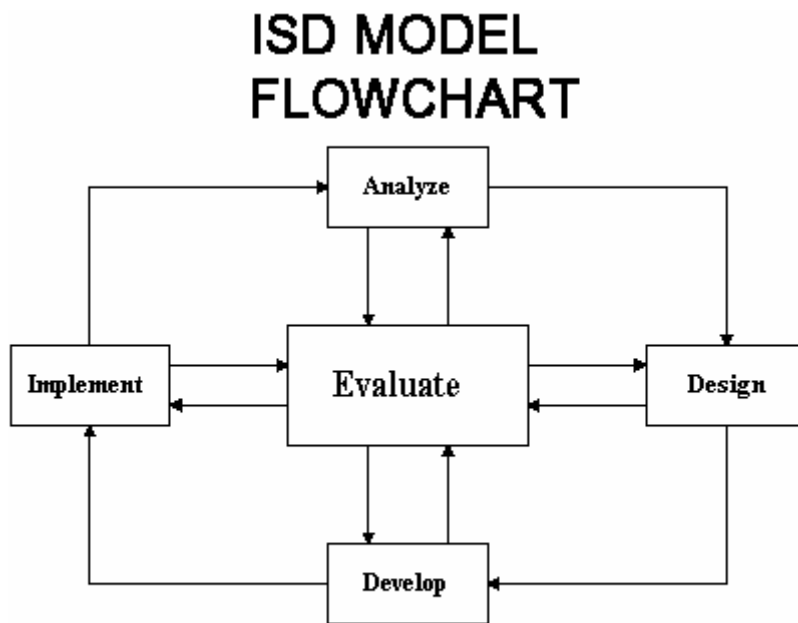


Figure 4. ADDIE Model (Huddle, C. 2002, presented by Ciavarelli and McCauley, 2006)

1. Goals of an HSI Training Evaluation

When the REF initiates a new product or technology, the potential for gaps between the skills required to operate the new product and the skills possessed by unit members is high (Niederman and Webster, 1998). Because the REF is usually not capable of making substantive changes in the design of the equipment or manipulating manpower and personnel requirements, training is the primary method for closing this gap (Office of the Deputy Chief of Staff G1, 2005). The goal of the HSI Training evaluation is to systematically analyze formal and informal instructional programs to ensure that when these programs are implemented skill levels increase and performance is improved for the total system (Air Force Human Systems Integration Office, 2003).

Training programs should be implemented to develop and sustain proficient individuals and units. Where possible, HSI seeks to leverage the increased levels of performance to reduce lifecycle costs (Malone and Miller, 2003). HSI Training evaluations should include: course design, development, and implementation; use of simulators and training aids; and, embedded training capabilities.

2. Training Evaluation in a Traditional Acquisition Setting

For traditional acquisitions, the Program Manager must design systems that are focused on the training needs of the Combatant Commander (Department of Defense, 2004). As with the Manpower, Personnel and Human Factors Engineering domains, an effective HSI Training evaluation begins with a Top Down Requirements Analysis (TDRA) and full Target Audience Description (TAD) (Malone and Miller, 2003). Analysts can identify required knowledge, skills, and abilities by conducting task and workload analyses for the system while it is under typical mission conditions and compare these required KSAs to those present in the target population. Where shortfalls exist in the target population, training analysts must determine if a training/instructional system can be designed to eliminate the deficiencies (Naval Sea Systems Command, 2005).

For any program to be effective, the Program Manager must design an affordable but effective training strategy, execute the development of the infrastructure required to complete the training, manage the resources necessary to provide effective training

throughout the system's lifecycle, and evaluate the effectiveness of the training (Office of the Deputy Chief of Staff G1, 2005). The training strategy should focus on options that take advantage of technologies in the areas of simulation, embedded training, and multimedia-based instruction to provide individual, team, and joint training opportunities to operators, maintainers, and support personnel. Any program requiring changes in training infrastructure require the Program Manager to explicitly identify schedule, technology, and funding risks that threaten program execution (Department of Defense, 2003).

Training programs should consider the varying needs of the following groups: civilians; contractors; and Active, Guard and Reserve officers; warrant officers; and, enlisted personnel. Additionally, training programs must also consider pipelines for instructors and other key personnel. In all cases, training requirements should be established to improve user capabilities and readiness while minimizing lifecycle costs, reducing the demand on the training system, and sustaining optimal performance of the system (Malone and Miller, 2003).

3. Specific Objective of an HSI Training Evaluation

- Identify knowledge, skill and ability shortfalls in the target population caused by the introduction of new technology, doctrine, and organizational changes (Kleiner and Booher, 2003; Malone and Miller, 2003).
- Develop training systems that allow operators, maintainers and supporters to interactively train and practice with the system while deployed or stationed remotely (Malone and Miller, 2003).
- Evaluate the effectiveness of training systems to ensure the most efficient, cost effective development of knowledge, skills and abilities in the target population (Department of Defense, 2004).
- Implement fault and failure conditions to allow maintainers and supporters the ability to rehearse repair procedures (Malone and Miller, 2003).
- Identify requirements for initial and refresher training needed to achieve desired performance standards (Malone and Miller, 2003).
- Promote training concepts that allow for anytime, anyplace training while easing the burden on legacy training systems and reducing total lifecycle costs (Malone and Miller, 2003).
- Verify training requirements are based on knowledge, skills and abilities required to perform operational assignments (Malone and Miller, 2003).

- Verify training is capable of supporting engineering designs (Department of Defense, 2004).

4. A Practical Training Evaluation for REF Systems

REF analysts must consider that system failures can result not only from failures of technology but also a lack of training (Turnage, 1990). Unfortunately, not all training programs are effective; training programs may have positive, negative or neutral effects (Burke, 1997). Training effects, or training transfer, are “the effective application, generalisability and maintenance of new knowledge, skills and abilities to the workplace, as a result of undertaking an educational strategy” (Holton and Bates, 2000). In order to maximize the potential for successful training interventions, the REF analyst must conduct an effective training needs analysis to identify the knowledge gaps created in the unit by the REF intervention (Goldstein, 1993).

Ideally, the REF would create short duration training programs to facilitate specific skill acquisition by:

- Conducting a full analysis of a training problem to establish a problem statement;
- Determining the goals of the training intervention; conducting a task/job analysis to understand skill gaps;
- Developing and classifying learning objectives;
- Determining the instructional strategy;
- Determining the best media to deliver the training;
- Formulating a training system concept;
- Defining measurement requirements for feedback and training effectiveness evaluations (Eisenstein 2005; Ciavarelli and McCauley 2006).

The goal of the training effectiveness evaluation is to produce information quantifying the transfer of training so that decision makers can maintain or modify the training system. (Bell and Waag, 1997)

The seminal work in the realm of training evaluation was conducted by Kirkpatrick (1959). Kirkpatrick proposed that analysts should evaluate training systems at four levels: the behavioral level, the learning level, the reaction level, and the result level. The behavioral level measures the trainee’s satisfaction with the training and training system. The learning level measures the knowledge, skills and abilities gained

from training. The reaction level measures how well the learning objectives of the training system are applied to on the job performance. The result level measures the overall effect of the training program on the organization as a whole (Kirkpatrick ,1959).

The implication of the Kirkpatrick model is that there is a cause and effect relationship in which training leads to reactions and the training reactions lead to learning. Learning leads to behavior changes which lead to changes in the overall organization (Hamblin, 1974). Holton has criticized this implication, calling the Kirkpatrick model little more than taxonomy as opposed to a fully developed theoretical construct (Holton, 1996). The limited research conducted on the validity of this linear relationship has been inconclusive (Lefkowitz 1972; Latham, Wexley et al., 1975).

Though designed for Information Systems evaluations, Hamilton & Chervany put forth two additional methods for effectiveness evaluation that could be applied to a rapid training analysis. The first, a goal-centered approach, is similar to the training program assessment mentioned above in that the analyst determines the objectives of the system or the units using the system and selects performance measurements based on this analysis. A training evaluation in this case would compare unit or individual performance to the objectives of the training system.

The second, and more interesting method, is a system-resource approach in which the analyst evaluates system effectiveness based on the attainment of a pre-established normative state. Conceptually, effectiveness would be measured in terms of resource viability vice specific task or unit objectives. The system resource method of effectiveness measurement is useful when the system to be evaluated must be used to accomplish tasks outside of the stated objectives or may have consequences beyond mission accomplishment (Hamilton and Chervany, 1981). As an example of the system-resource approach, consider analysis of the use of tent pegs. The task analysis for tent pegs may only involve hammering them into the ground, but the consequence of not having the tent pegs could be degraded performance due to increased troop fatigue because of the lack of shelter.

Unfortunately, the REF analyst cannot generally work through these time intensive processes due to the constraints imposed by the customer's operational

assignment. No matter which approach to conducting a training evaluation is used, unambiguous measures of training transfer are difficult to come by. The training evaluation literature supports two types of evaluation: behavioral measurement and self-reported evaluation. Behavioral measurement is difficult to conduct because it requires direct observation. While using video cameras or facilities such as a usability lab are possible, the limitations of this method effectively constrain its use to a laboratory or fixed simulator setting (Haccoun and Saks, 1998).

Self-report surveys and tests are the most commonly used method to evaluate a training program (Axtell, Maitlis, 1997). These surveys are normally administered at the completion of the training course and ask the trainee's subjective reaction to the training in questions that can either be qualified as affective natured (how well did you like the instructor) or utility natured (how useful do you feel the training program will be to your job). The correlation between these reactions (both affective and utility) and on-the-job performance was found to be better correlated than reaction measures and immediate and retained measures of learning, but both correlations were extremely low and not recommended as a replacement for a more complete analysis (Alliger and Tannenbaum, 1997).

Of course, the validity of self-reported data is always a concern. One possible way to increase the confidence in self-reported data is to use a multiple perspective evaluation, similar to the 360-degree feedback concept used for employee performance evaluations. By measuring the trainee, the supervisor, and the trainee's followers, an evaluator may be able to get a more precise evaluation of the effect of the training on job performance (Haccoun and Saks 1998).

A model that some researchers believe is helpful in predicting training transfer is the Valance, Instrumentality, and Expectancy (VIE) model (Mathieu and Tannenbaum, 1992; Haccoun, 1997). In theory, if the trainee believes that he will be able to use the training to improve his job performance (Efficacy), believes the training has value and is useful to his future job performance (Valance), and believes that he will be able to

implement the lessons and techniques learned in training (Instrumentality) then this trainee will be more likely to experience training transfer than a trainee that is missing one or more of these elements.

Utility reaction measures seem to measure the Value of the course to the trainee. Affective reaction measures can be designed to measure the trainee's self-efficacy and motivation. A study of the trainee's work environment can provide a measure of Instrumentality.

Although they did not comment specifically on the VIE model, Baldwin and Ford (1988) put forth a model that could easily incorporate the VIE model. The Baldwin and Ford model, Figure 5, has three training inputs: Trainee Characteristics (which would include motivation and efficacy), Training Design (which should consider factors that make up the Valance measure), and Work Environment (which would include factors that contribute to Instrumentality) (Baldwin and Ford, 1988).

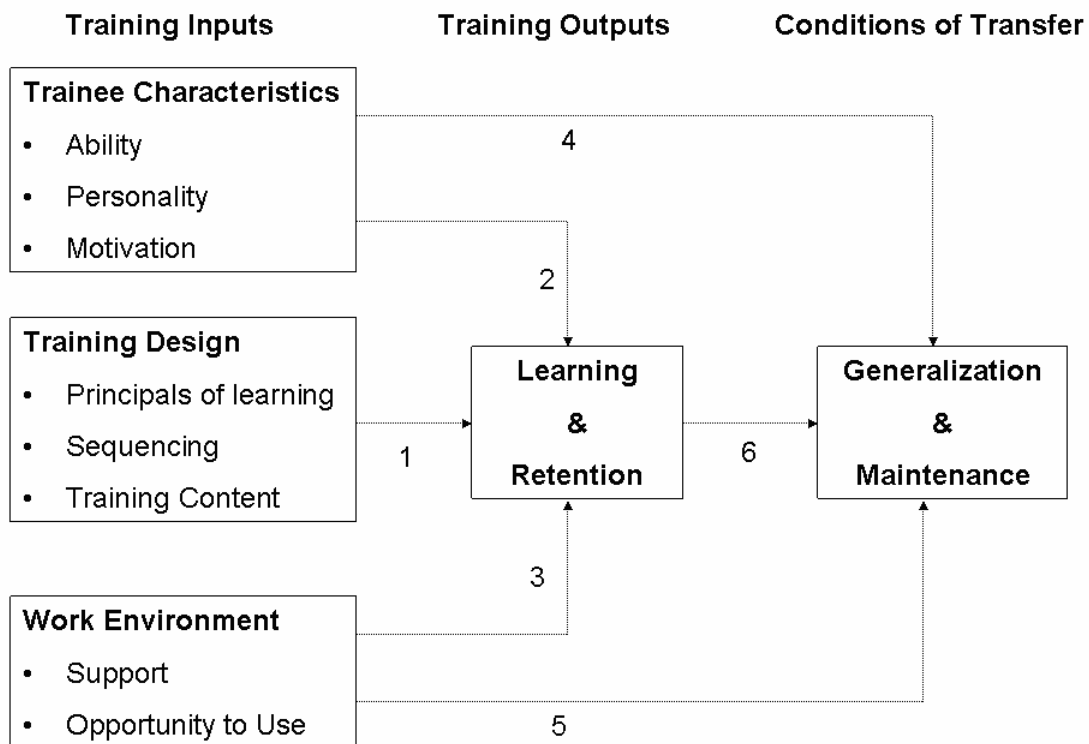


Figure 5. Model of the Transfer Process (Baldwin and Ford, 1998)

In the Baldwin and Ford model, VIE factors have a direct effect on learning and retention while efficacy and instrumentality factors directly impact learning and retention and generalization and maintenance of the training.

Clearly, individual differences such as cognitive ability and motivation impact the transfer of training the job performance (Sein and Bostrom, 1989). There have been a limited number of studies in which researchers have attempted to evaluate specific measures of individual differences to predict training effectiveness. There have been even fewer studies in which multiple factors of the VIE model have been studied together (Baldwin and Ford, 1988). These studies have met with mixed results and do not offer clear guidelines for use in a predictive model at this time (Tan and Hall, 2003).

While the scholarly literature does not provide specific guidelines, there are some general concepts that should be considered. First, trainee self-efficacy is important (Haccoun and Saks, 1998). Moreover, the relevance of the course sets the stage for trainee motivation and desire to learn. Training relevance and trainee motivation are critical variables in predicting the level of training transfer trainees self-reported after one month (Axtell and Maitlis, 1997).

One year removed from training, the original motivation level, level of autonomy on the job, and the amount of training transferred after one month are strong predictors (Axtell and Maitlis, 1997). Support from subordinates, peers, and superiors within the organization can also impact training transfer (Salas and Cannon-Bowers, 2001). As Baldwin and Ford (1988) indicated in their model, organizational support impacts both initial knowledge acquisition and long-term transfer of training.

Training transfer should be evaluated no more than one to three weeks following the beginning of use of the product in a true operational setting (Mahapatra and Lai, 2005). Delays between training and actual use can result in significant knowledge/skill decay (Salas and Cannon-Bowers, 2001). In one study, trainees were immediately able to recall and utilize 40% of the training material but only 25% after six months and 15%

after being removed from training for one year (Burke, 1997). If there is an expectation of a long delay between training and use, refresher training is recommended (Antle and Barbee, 2003).

No matter how comprehensive the training program, it is not reasonable to believe that a training intervention alone will guarantee changes in work practice or long term organizational outcomes (Baldwin and Ford, 1988; Sein and Bostrom, 1989). To help maximize training transfer and the effective use of REF equipment, it may be necessary to inform trainees of specific situations that may limit the use of new skills and teach trainees how to recognize possible barriers to effective use of the training concepts. The REF must also supply the trainee with methods to overcome unfavorable environmental conditions, and encourage the trainee to use these mediation methods in difficult situations (Marx, 1982).

Finally, training is believed to be most effective when the training program “instills general principles, and a multiplicity of practical examples and demonstrations of the learning points” through maximum repetition of experiential learning vice passive learning techniques (Haccoun and Saks, 1998).

Without the ability to fully design and implement its own instructional system or manipulate manpower and personnel requirements, the REF must capitalize on the effects of training by preparing Soldiers to obtain the highest possible of transfer. Without considering individual, organizational, and training design factors, it will be difficult for the REF to make informed decisions as to whether the limitations of a piece of equipment are due to technological failures or due to poor training design or transfer. This discussion of the Training domain suggests several questions that the REF analyst could pose to evaluate a proposed training system (refer to the Training portion of appendix A for questions).

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VI. THE HABITABILITY DOMAIN

A. HABITABILITY DEFINED

The Habitability domain of HSI refers to “those issues associated with the living, sleeping and eating within the confines of the system” (Miller, N. L., Crowson, J., and Narkevicius, J. M., 2003, p.726).

B. HSI, HABITABILITY, AND THE REF

Since most of the systems procured through the REF will not involve evaluations of living/working space, temperature, sanitation or ventilation, the habitability evaluation for the REF will likely be limited to two important factors: (1) improving Soldier quality of life and (2) providing initial consideration for habitability from a system of systems perspective.

In the area of quality of life, the REF analyst should consider how the human machine interface, training provisions, and doctrinal implementation of the system affect the Soldier’s performance of his/her duties, and enhance job satisfaction, job enlargement, and enrichment. Where applicable, habitability trade-offs should reduce physical and psychological stress to ensure that Soldiers are rested, vigilant, motivated and unimpaired (Malone and Miller, 2003).

The REF analyst should also consider the new system as a part of a system of systems. This evaluation should determine the impact that the new system will have on other systems with which it may be employed. More specifically, when the REF equips a unit with a new piece of gear, the analyst should consider how the new equipment may affect the habitability of systems used to transport the Soldiers in the field (Department of Defense, 2003).

1. Goals of an HSI Habitability Evaluation

The HSI analyst conducts a habitability evaluation to identify and address any factors related to living or working conditions that might be required for extended system employment. The specific goal of a habitability evaluation is to “optimize mission readiness, crew morale, professional development, retention, and recruitment that support system performance” (Naval Sea Systems Command, 2005).

Habitability factors, including Soldier morale and comfort, quality of life issues, and physical environment, cannot be endlessly sacrificed for other engineering priorities or HSI domain requirements without eventually impacting personnel performance, unit readiness, and recruiting and retention (Department of Defense, 2003; Malone and Miller, 2003; Department of Defense, 2004). A well-executed implementation of habitability factors can significantly ease requirements in the HSI domains of Manpower and Personnel.

2. Habitability Evaluation in a Traditional Acquisition Setting

A comprehensive habitability examination may be more applicable for large systems such as the Navy's ship procurement and large ground systems such as the M1A1 tank. In such systems, the HSI professional would work with engineers to establish acceptable system standards for living/working space, temperature, noise, lighting, ventilation and sanitation (where applicable). In establishing these standards, there may be significant overlap with the HSI domains of System Safety, Environment, Safety and Occupational Health (ESOH), and Soldier Survivability (Department of Defense, 2004).

As Doctrine, Organization, and Leadership become more solidified the HSI professional should also consider the personal services required by the Soldiers operating, maintaining, and supporting the system. These personal services may include provisions for messing, religious services, and mail or other methods of communication. These habitability determinations would be geared at improving quality of life issues during sustained operations that would have a direct impact on retention and recruiting requirements. This discussion of the Habitability domain suggests several questions that the REF analyst could pose to evaluate the Habitability domain (refer to the Habitability portion of appendix A for questions).

3. Specific Objectives of an HSI Habitability Evaluation

- Identify habitability requirements (physical environment, requirements for personnel services, and living conditions) required to sustain system performance, promote personnel recruiting/ problems, and maintain quality of life (Malone and Miller, 2003).

- Analyze the impact of ventilation, noise, lighting, messing, berthing, sanitation, and quality of life initiatives on sustaining performance requirements and sustaining mission effectiveness (Malone and Miller, 2003).
- Ensure that stowage of gear does not impact crew habitability (Malone and Miller, 2003).
- Verify safety issues are identified and corrected, shielded or guarded (Malone and Miller, 2003).
- Verify that system layout allows for comfortable operation, maintenance and support of the system (Malone and Miller, 2003).

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VII. SURVIVABILITY

A. SURVIVABILITY DEFINED

The Department of Defense (DoD) has addressed survivability from the perspective that personnel endurance is essential to mission accomplishment. The DoD acknowledges that in combat, risks include accidental death of Soldiers, nuclear, chemical, and biological hazards, environmental limitations, and the necessity for immediate evacuation during life-threatening system conditions. Given these particular threats, “the PM must address the system and potential supplements in order to optimize the survivability of the personnel as well as the system itself” (Department Of Defense 5000.2, 2003).

Army Regulation (AR) 70-75 (2005) supplements the DoD’s guidelines with a specific distinction between two elements of survivability: Soldier and system. Soldier survivability focuses on the ability of the Soldier to not only survive when carrying out a mission but also persist with effective performance within decreased system capabilities. Mission accomplishment relies upon the survivability of the system as well. Survivability is enhanced when systems are designed to endure (i.e., withstand) hostile environments or avoid them all together.

B. SURVIVABILITY DOMAIN IN HSI

HSI addresses survivability in a manner that considers both personnel and system factors simultaneously. The DoD 5000.2 (2003) states “the PM shall address personnel survivability issues including protection against fratricide, detection, and instantaneous, cumulative, and residual nuclear, biological, and chemical effects; the integrity of the crew compartment; and provisions for rapid egress when the system is severely damaged or destroyed. The PM shall address special equipment or gear needed to sustain crew operations in the operational environment” (Department of Defense 5000.2c, 2003, p. 33). Although similar, Zigler and Weiss’ HSI approach to survivability slightly differs from the DoD and Army approach. HSI examines the Soldier and system as interconnected variables. Because HSI centralizes the impact of the human within the system, HSI analysts view survivability as “...man-machine interaction and the effects as

a whole with the ultimate focus on the survival of the human” (Zigler and Weiss, 2003 p.627). Therefore, personnel survivability is intricately interwoven with the system’s survivability. According to Malone and Miller (2003), survivability of personnel depends upon the design of a system that reduces “...the risk of fratricide, detectability, and probability of being attacked” (p. 38). Ultimately, such actions allow personnel to accomplish the mission, endure hostile environments, and mitigate the effects of chronic illness, disability, death, or abort the mission (Malone and Miller, 2003). The HSI perspective aligns with the six principals of the military personnel domain (Zigler and Weiss, 2003):

- Reduce fratricide
- Reduce detection
- Reduce probability of being attacked
- Reduce damage
- Minimize injury
- Reduce mental and physical fatigue

C. HSI, SURVIVABILITY, AND THE REF

The mission of the REF is to “...provide operational commanders with rapidly employable solutions to enhance lethality, survivability and force protection through insertion of COTS-GOTS (Equip) and Future Force technologies (Insert) while informing Army stakeholders (Assess) to remain ahead of an adaptive enemy” (www.ref.army.mil). HSI analysts contribute to this mission by conducting analyses that optimize the survivability of the personnel and the system by suggesting alternatives that mitigate the vulnerabilities and threats that front-line troops often confront. By applying an analytical approach that views personnel and system survivability as interwoven factors, HSI analysts ensure optimal performance. Stated differently, system survivability is not optimal if personnel cannot endure environmental or hostile conditions. Therefore, the HSI practitioner must be concerned about both areas of survivability; this provides the most comprehensive and valuable approach.

1. Goals of an HSI Survivability Evaluation

Under peacetime operating conditions, reduction of injury and death is the focal point in the domains of Human Factors Engineering, Habitability, and Environment,

Safety and Occupational Health. The Survivability domain is focused on combat and attempts to reduce an obvious scenario (Kleiner and Booher, 2003). As an example of this distinction, consider an obvious scenario. Under peacetime conditions, analysts in Human Factors Engineering, Habitability, and Environment, Safety and Occupational Health could design a tent that best protects its occupants from the weather: they may give no consideration to the color of the tent. This tent that meets all peacetime requirements might be problematic under combat conditions if it were colored Dayglo Yellow; survivability analysts would make recommendations to correct this deficiency by selecting a color that would be more difficult for the enemy to detect.

The goals of an evaluation in the survivability domain are to influence system design to reduce the likelihood that an enemy might detect and attack our Soldiers and to increase the ability of Soldiers to withstand injury when attacked. During the survivability evaluation consideration must also be given to the risk of fratricide and measures to prevent fratricide episodes, both those inflicted by other units on the system being evaluated and those inflicted by the system being evaluated on other units (Department of Defense, 2004).

While the concept of survivability should be applied to both human and system, the HSI domain of survivability should be focused primarily on survivability of the human (Kleiner and Booher, 2003). Specifically, the survivability analyst should examine the instantaneous, cumulative, and residual effects of chemical, biological, radiological, nuclear, and explosive (CBRNE) attacks on the ability to continue operations without exposing Soldiers to acute chronic illness, disability, or death (Department of Defense, 2004). The survivability evaluation should also consider antiterrorism/force protection (AT/FP) measures, the impact of Mission Oriented Protective Posture (MOPP) gear or other protective equipment on operations, reduction of mental and physical fatigue, crew compartment integrity and rapid egress capabilities for systems that have been damaged or destroyed (Air Force Human Systems Integration Office, 2003; Malone and Miller 2003; Department of Defense, 2004; Office of the Deputy Chief of Staff G1, 2005).

2. Survivability Evaluation in a Traditional Acquisition Setting

At the beginning of a traditional acquisition program (pre-Milestone B), the new system's design, operating environment, and doctrine may lack sufficient detail to permit critical analysis. Throughout the acquisition lifecycle the Program Manager must implement an iterative Personnel Survivability program that reduces detection and attack by the enemy, minimizes serious injury by operator and maintenance personnel, and prevents fratricidal incidents (Department of Defense, 2004). As concept refinement and system development become more mature, survivability analysis can become more robust.

Survivability assessment is primarily conducted in the Low Rate Initial Production phase. During this phase, the system will undergo initial operational test and evaluation and live fire testing. Of course, not all aspects of survivability can be addressed in test and evaluation, and the Program Manager should supplement test and evaluation with modeling and simulation.

To fully address survivability, the domain is generally divided into seven components: (1) Reducing Fratricide, (2) Reducing Detectability, (3) Reducing Probability of Attack, (4) Minimizing Damage, (5) Minimizing Injury, (6) Minimizing Physical and Mental Fatigue, and (7) Surviving Extreme Environments (Malone and Miller 2003; Department of Defense, 2004). These seven components can be addressed through methods as basic as use of camouflage, smoke, and deception techniques that make the system appear like a target of lesser value or through more technological interventions such as signal distortion, Identification of Friend or Foe (IFF) technology, and countermeasure systems. Additionally, Program Managers may also be able to influence survivability through training, doctrinal change, human factors engineering (Malone and Miller 2003; Department of Defense, 2004). Chapter Six of the Defense Acquisition Guidebook provides a more complete description of these seven survivability components (Department of Defense Acquisition Guidebook, 2004).

3. Specific Objectives of an HSI Survivability Evaluation

- Identify doctrine, training and technological initiatives to improve the ability to correctly identify/be correctly identified by friendly forces (Malone and Miller, 2003).
- Identify specific methods to reduce the probability of detection and attack by enemy forces (Malone and Miller, 2003).
- Identify personal protective gear/equipment required to minimize injury, illness and death caused by instantaneous, cumulative and residual CBRNE weapon effects (Malone and Miller, 2003).
- Maximize crew compartment integrity during combat operations (Malone and Miller, 2003).
- Ensure viability of planned rapid egress methods given severe system damage/destruction (Malone and Miller, 2003) .
- Verify the design of personnel survivability alarms and alerts effectively convey required information to crew members (Malone and Miller, 2003).
- Ensure damage control tasks have been assessed after completion of final equipment and system installations (Malone and Miller, 2003).
- Continually evaluate the following Survivability high drivers for changes in risk assessment and system survivability (Air Force Human Systems Integration Office, 2003):
 - New weapons technology.
 - Weapons designed for crew incapacitation.
 - Weapons designed to inflict damage on the system.
 - New Radar technologies that increase detectability.
 - Adverse changes in operating environments.
 - Changes in own/enemy doctrine.

4. A Practical Survivability Evaluation for REF Systems

The HSI domain of survivability aligns with two of the REF's primary focus areas: survivability and force protection. It is likely that many of the REF NDI solutions will be developed exclusively for use in the civilian sector, and as such, will not have been evaluated with the demands of the combat environment in mind. Fortunately, the REF analyst will be supported by the Army Test and Evaluation Command (ATEC), which will provide a basic safety analysis for the equipment.

While ATEC will provide the REF with a limited objective evaluation of the system, the REF analyst can supplement this evaluation with a subjective global assessment to identify critical survivability issues. To support any commercial survivability analysis conducted, the REF analyst should consider the “availability/adequacy of protection systems and devices, expected human performance wearing protective ensembles, adequacy of countermeasures, and adequacy of the design for survivability” (Malone and Miller, 2003 p. 124). In order to conduct this overarching subjective evaluation, the REF analyst must determine early in the equipping process the doctrine and environment against which systems must be evaluated.

The overarching subjective evaluation might use a system similar to the risk management matrix in which the severity of the consequence is compared to the probability of occurrence (Clark and Goulder, 2002). To standardize measures of severity, the REF analyst should use the following delineation: “[Category 1] – Catastrophic – may cause death or system loss; [Category 2] – Critical – may cause severe bodily injury, severe, occupational illness, or major system damage; [Category 3] – Marginal – may cause minor bodily injury, minor occupational illness, or minor system damage; and [Category 4] – Negligible – may cause less than minor bodily injury, occupational illness, or minor system damage” (Clark and Goulder, 2002 p. 90).

No organization is capable of addressing every survivability concern, and it is appropriate for the REF analyst to consider contingency management techniques and expected performance given damage to selected systems. If a deficiency is noted through any method of evaluation then the REF analyst should make recommendations to address the deficiency through system design, training, or other protective measures (Malone and Miller, 2003). Any decision to accept potential risks should be formally documented by the REF analyst and forwarded to the decision maker for consideration (Naval Sea Systems Command, 2005).

This discussion of the Survivability domain suggests several questions that the REF analyst could pose to evaluate the Survivability domain (refer to the Survivability portion of appendix A for questions).

VIII. THE ENVIRONMENT, SAFETY, AND OCCUPATIONAL HEALTH (ESOH) DOMAIN

A. ESOH DEFINED

The Department of Defense Instruction 5000.2 (2003) addresses the ESOH domain in three distinct sections. The environmental aspects of this instruction direct the Program Manager to analyze the impact of the system on its surrounding environment as it relates to safety. The safety portion of this instruction instructs the PM to evaluate all safety programs that apply to the system, as well as the impact on the operators and maintainers. Finally, the occupational health section of this instruction investigates whether the well being of the operators and maintainers is continually considered.

Due to the general nature of the DoD instruction for safety, the Army developed detailed policies and published them Army Regulation (AR) 385-10. The Department of Labor (DoL) standards were used as guiding principles for minimum standards. These policies and procedures, are designed to prevent injury or damage to Army personnel or property (AR 385-10, 2002).

AR 385-16, System Safety Engineering and Management, provides the system safety engineering and management guidelines for Army safety throughout the acquisition process (Army Regulation 385-16, 2004). Specifically, this regulation prescribes policies and procedures that ensure systems and facilities hazards and their associated risks are identified throughout the lifecycle of the system. AR 385-16 also ensures that safety programs are implemented for all nondevelopmental items (NDI). Therefore, the same guiding principles and minimum standards apply for NDIs such that "...application of system safety should start immediately after definition and identification of need" (AR 385-16, 2004).

B. ESOH DOMAIN IN HSI

Unlike other domains within HSI, the ESOH domain is more mature due to it being based on the DoL ESOH guidelines. The HSI practitioner's main focus within the ESOH domain is to ensure that all safety regulations are being adhered to throughout the

system's lifecycle. In addition, the HSI practitioner ensures that the tradeoff between the various domains does not create circumstances in which the safety factors fall below minimum standards.

C. HSI, ESOH, AND THE REF

Due to the nature of the systems the REF employs, the REF analyst must ensure that safety criteria are strictly adhered to from the outset of the REF acquisition process. Not only should the minimum safety standards be applied, but also stricter standards should be considered due to the environment in which the system will be employed.

1. Goals of an HSI Environment, Safety and Occupational Health (ESOH) Evaluation

The goal of an Environment, Safety and Occupational Health (ESOH) evaluation is to protect the operators, maintainers, supporters and their environments from unnecessary risks that may result in injury, illness, or death (Office of the Deputy Chief of Staff G1, 2005). ESOH evaluations differ from Survivability evaluations in that the Survivability evaluation is based on operations in a combat or threat environment (Malone and Miller, 2003). As an example, an ESOH evaluation of a helicopter may focus on environment, safety, and health issues of standard operations whereas a survivability evaluation would examine how these issues are complicated by enemy detection, attack, and lethality capabilities.

ESOH evaluations are generally divided into two sections: System Safety and Health Hazards. System Safety examinations seek to minimize or eliminate factors that may lead to human or machine errors/failures that will potentially result in a mishap causing injury or death. A Health Hazard examination explores system design and concept of operations to identify factors that will result in significant risk of injury, illness, or death (Malone and Miller, 2003).

ESOH evaluations can result in changes to system design or operating concept that minimize manpower, personnel, and training requirements (Air Force Human Systems Integration Office, 2003). The Navy's Mk V Special Operations Craft demonstrates this concept. The craft experiences slamming rated at up to 20g which results in performance-degrading injury to 30 percent of Special Warfare Combat

Crewmen (McCarter, 2004). If the effects of the ship's impacts could be minimized then manpower and personnel initiatives to replace and train this 30 percent of crewmen could be eliminated over the lifecycle of the system.

An effective ESOH evaluation should result in minimizing both the potential for mishap and the consequences of mishaps that are unavoidable. Minimizing risk/impact should increase operational readiness and mission effectiveness and reduce damage to the environment and loss of equipment (Air Force Human Systems Integration Office, 2003).

2. Environment, Safety and Occupational Health (ESOH) Evaluation in a Traditional Acquisition Setting

Throughout the acquisition lifecycle the program manager must implement an iterative ESOH program that will minimize injury, illness, and death of operators, maintainers, and support personnel and minimizes damage to equipment and environment (Department of Defense, 2004). Specifically, the program manager should address risks by concentrating on ESOH concerns early in the systems engineering process, identifying a method for tracking ESOH progress, and developing a schedule for the system to become fully compliant (Department of Defense, 2003). The ESOH program should consider problematic system design features; use of hazardous materials; exposure to toxic chemicals; environmental stressors such as thermal, vibration, noise, and electrical and other fluid discharge (Malone and Miller, 2003).

The ESOH evaluation should examine all operations, support, and maintenance situations that Soldiers should expect to experience during the lifecycle of the system. Early in the acquisition process, it is often difficult to establish measurable safety and health requirements due to the preliminary nature of the system design and operational concepts. Requirements at this stage of the process are typically generated from lessons learned from human factors issues in comparable or predecessor systems. Later in the acquisition process, requirements can be altered to meet system-specific issues that can be analyzed using MIL-STD-882 series and other safety guidelines (Air Force Human Systems Integration Office, 2003; Malone and Miller, 2003).

When Manpower, Personnel, Training, or Human Factors Engineering cannot be altered to eliminate ESOH hazards, the Program Manager must identify the risks,

prioritize the risks by severity, determine how to mitigate the risks, and formally accept any risks that could not be eliminated. The Program Manager should also define allowable levels of risk in accordance with standards set forth in MIL-STD-882D and other safety regulations. In all instances, the Program Manager must document any risks that were accepted throughout the lifecycle and any hazardous materials with which operators and maintainers may come into contact (Air Force Human Systems Integration Office, 2003; Malone and Miller, 2003).

Areas of consideration may include, but are not limited to: threats from acoustic energy; biological and chemical substances; atmospheric hazards; ionizing and non-ionizing radiation; fire and explosions; shock; pressure extremes; temperature extremes and humidity; trauma; vibration, and uncontrolled mechanical, electrical or fluid energy releases (Malone and Miller, 2003; Department of Defense, 2004).

3. Specific Objectives of an HSI Environment, Safety and Occupational Health (ESOH) Evaluation

- Eliminate or minimize injury, death, and lost work hours of system operators, maintainers, and supporters caused by instantaneous, cumulative and residual effects of system use (Malone and Miller, 2003).
- Develop a system safety plan (Malone and Miller, 2003).
- Review preliminary engineering designs for safety limitations (Malone and Miller, 2003).
- Eliminate or minimize safety risks associated with the system through an iterative review process (Malone and Miller, 2003).
- Document safety requirements to be implemented in system specification/design (Malone and Miller, 2003).
- Conduct a HSI/DOTMLPF trade-off analysis to ensure safety requirements do not invalidate assumptions made in other domains (Malone and Miller, 2003).
- Complete a safety and health analysis to identify unacceptable risks associated with the system design and planned implementation (Malone and Miller, 2003).
- Identify any special tests required to demonstrate or otherwise verify the proper functioning of safety designs and equipment (Malone and Miller, 2003).
- Collect data on safety testing, failure analysis, mishap reports, and other system tests with safety implications for analysis and decision support (Malone and Miller, 2003).
- Ensure required warnings, cautions, and special safety procedures are documented, posted, and supported with training (Malone and Miller, 2003).

- Test safety and warning devices, life support equipment, and personal protective equipment for effectiveness in all anticipated operating environments (Malone and Miller, 2003).

4. A Practical Environment, Safety and Occupational Health (ESOH) Evaluation for REF Systems

The REF is procuring many of its products from the commercial sector, and it is likely that the product manufacturers have conducted safety analyses during product development in order to avoid the consequences of a liability lawsuit. However, but the REF analyst should not simply accept this assumption without verifying that testing was conducted and the reported results are valid. Even if testing was conducted by the manufacturer, the REF analyst must verify that the results of the testing can be generalized to the system's military concept of operations.

To assist with this determination, the REF analyst is supported by the Army Test and Evaluation Command (ATEC). For new REF products, ATEC will provide an objective Safety Certification for the system. For REF systems with repercussions on survivability and lethality, ATEC will include a Capabilities and Limitations Report with the Safety Certification (Defense Acquisition University, 2006). While the ATEC Safety Certification is beneficial to the REF process, evaluations of complex systems may be time consuming and significantly delay delivery of the equipment to the field.

The REF analyst may be able to facilitate the ATEC analysis by providing an initial subjective assessment of the system to identify critical ESOH risks. The goals of this analysis would be to eliminate products with gross safety concerns and provide a focus for further objective safety evaluations. The overarching subjective evaluation might use a system similar to the risk management matrix in which the severity of the consequence is compared to the probability of occurrence (Clark and Goulder, 2002). As with all other domains, to standardize measures of severity, the REF analyst should use the following delineation: "[Category 1] – Catastrophic – may cause death or system loss; [Category 2] – Critical – may cause severe bodily injury, severe, occupational illness, or major system damage; [Category 3] – Marginal – may cause minor bodily injury, minor

occupational illness, or minor system damage; and [Category 4] – Negligible – may cause less than minor bodily injury, occupational illness, or minor system damage” (Clark and Goulder, 2002 p. 90).

If a deficiency is noted through any method of evaluation, the REF analyst should make recommendations to address the deficiency through system design, training, or other protective measures (Malone and Miller, 2003). Any decision to accept potential risks should be formally documented by the REF analyst and forwarded to the decision maker for consideration (Naval Sea Systems Command, 2005).

This discussion of the ESOH domain suggests several questions that the REF analyst could pose to evaluate the ESOH domain (refer to the ESOH portion of appendix A for questions).

IX. HUMAN FACTORS DOMAIN

A. HUMAN FACTORS DEFINED

Human Factor Engineering (HFE) is a multidisciplinary domain, which includes topics that encompass all aspects of human-system to human interactions. The factors associated with HFE are (Critical Process Assessment Tool, 1998):

- “Anthropometrics Factor – Human Physical Dimensions, Body Posture, Repetitive Motion, Physical Interface.”
- “Sensory Factors – Hearing, Vision, Touch, Balance.”
- “Cognitive Factors – Mental Ability, Skills, Decision Making, Training Requirements.”
- “Psychological Factors – Human Needs, Attitudes, Expectations, Motivations.”
- “Physiological Factors – Human Reactions to Environments, Strength (lifts, grip, carrying, etc.), Endurance.”

According to the Handbook of Human Factors, “Human Factors Engineering (HFE) and applied ergonomics are concerned with the application of the data and principals of human factors and ergonomics to the design of equipment, subsystems, and systems” (Christensen, 1987, p. 8). This perspective implies that human factors engineering and ergonomics are synonymous terms and the focus is the overall improvement of systems and working conditions between the human and the system. This definition serves as the foundation on which the DoD has based its HFE instruction.

AR 602-1 is the regulation governing HFE within the Army. This regulation defines HFE “as a comprehensive technical effort to integrate all personnel characteristics (skills, training implications, behavioral reactions, human performance, anthropometric data and biomedical factors) into Army doctrine and systems to assure operational effectiveness, safety, and freedom from health hazards” (AR 602-1, 1986, p. 1).

B. HUMAN FACTORS DOMAIN IN HSI

The human factors domain in HSI has adopted the definition used by the Army MANPRINT program. It supplements that AR 602-1 by emphasizing the integration aspect. Specifically, this definition addresses HFE as “the integration of human

characteristics into system definition, design, development and evaluation to optimize human-machine performance under operational conditions” (www.manprint.army.mil/manprint/index.htm). The HSI practitioner’s primary concerns in relation to the human factors domain is to ensure the program manager considers HFE during the early stages of the system lifecycle and to ensure that HFE issues are considered throughout the lifecycle of the program. The benefit of this process is that potential cost-effective measures are taken and that “system designs will minimize or eliminate system characteristics that require excessive cognitive, physical, or sensory skills; entail extensive training or workload-intensive tasks; result in mission-critical errors; or produce safety or health hazards” (Department of Defense, 2003).

C. HSI, HUMAN FACTORS AND THE REF

The challenges presented to the REF within the human factors domain are twofold. The first challenge the REF encounters is the alignment between the product’s specifications and the user population. Within the traditional acquisition approach to system development, products are customized for the specific user population. However, the types of products the REF acquires are not constrained to government or military user populations. Given that the products the REF deploys are generally NDIs/ COTS and are normally designed for the general public, there is no guarantee that these products can be fielded for operational use and are designed for the typical military Soldier user.

The second challenge is the manner in which HFE interacts with other domains. For example, if a product forces a Soldier to be cognitively overloaded while on a dangerous mission, it could lead to a severe decrease in the Soldier’s survivability. Therefore, the REF analyst must consider the impact HFE issues (i.e., psychological, cognitive, anthropometrics, sensory, and physiological) on other domains and how other domains on HFE.

1. Goal of an HSI Human Factors Engineering Evaluation

One of the goals of a Human Factors Engineering evaluation is to incorporate the capabilities and limitations of the operators, maintainers, and supporters into the definition, design and development of systems to maximize mission effectiveness while ensuring the system meets performance criteria for safety, habitability, and survivability

(Department of Defense, 2003). When employed effectively, Human Factors Engineering optimizes the mix of manpower, personnel and training by minimizing or eliminating system characteristics that require unusual or unusually high levels of knowledge, skills, or cognitive, sensory or physical abilities. Ineffective employment of HFE may result in excessive workload or require excessive training to prevent mission critical errors that would lead to unacceptable levels of injury or death (Department of Defense, 2003; Department of Defense, 2004). Unfortunately, variances in the military population mean that no system can be designed to fully accommodate all users. The challenge in HFE is to design system's to accommodate as large a portion of the population as possible.

Human Factors Engineering examines human-system interaction, including: human-computer interfaces, human-machine design, system software, communications, maintenance, procedures, and working environment (Malone and Miller, 2003; HSI VIRTUAL SYSCOM WORKING GROUP, 2005). Human Factors Engineering seeks to develop improved interfaces to achieve required levels of performance effectiveness during operations, maintenance, and support activities thereby allowing decision makers to make economically sound decisions concerning manpower, personnel, training and cost (Malone and Miller, 2003). Generally, Human Factors Engineering also considers system failures that lead to (or have the potential to lead to) catastrophic incident. (Wickens and Lee, 2003).

2. Human Factors Engineering Evaluation in a Traditional Acquisition Setting

DoD Instruction 5000.2 directs the program manager to “take steps (e.g., contract deliverables and Government/contractor IPT teams) to ensure human factors engineering/cognitive engineering is employed during systems engineering over the life of the program to provide for effective human-machine interfaces and to meet HSI requirements” (Department of Defense, 2003). Work in Human Factors Engineering should begin during the Concept Refinement and Technology Development phases of the acquisition lifecycle to ensure that the concepts for system performance do not exceed the capabilities of the target audience (Malone and Miller, 2003). In these early acquisition phases, Human Factors Engineering analysts evaluate legacy systems and expected

operator tasks to determine user needs and identify and parse required functions, tasks, and workload using Top Down Requirement Analysis (TDRA) and to other methodologies as described in MIL-HDBK-46855A (Department of Defense, 2004; Office of the Deputy Chief of Staff G1, 2005).

The TDRA should begin with a baseline scenario used to develop a mission and to define required functions for accomplishment of mission objectives. Function should be broken down into the tasks required to accomplish each function. Finally, each task should be analyzed to define required human performance parameters given the envisioned/tactical environment and system capabilities (Department of Defense, 2004).

Human Factors Engineering requirements are normally stated in terms of the user population as it relates to the cognitive, sensory, or physical knowledge, skills, or abilities. Cognitive requirements are normally stated as response times or measures of accuracy and reliability. Physical requirements are stated as either anthropometric, strength or weight standards. Sensory requirements are normally stated as visual, auditory, or olfactory standards (Department of Defense, 2004).

As the system moves from Concept Refinement and Technology Development to System Development and Demonstration phase of the acquisition lifecycle, HFE analysts become more involved with testing design alternatives using mock-ups, modeling and simulation, and system prototypes (Office of the Deputy Chief of Staff G1, 2005). During this phase of the acquisition lifecycle, the HFE analysts should specify requirements for human-machine and human-computer interface design by addressing the eight classes of interfaces - functional, informational, environmental, cooperational, organizational, operational, cognitive, and physical – required for effective human performance (Malone and Miller, 2003; Department of Defense, 2004). HFE tools such as the NASA Task Load Index (NASA TLX), IMPRINT, and JACK (human figure modeling software) assist the analyst in identifying KSA thresholds for the target population to be used in planning and later testing evolutions (Department of Defense, 2004).

Once the system moves to the Low Rate Initial Production phase and into Operational Test and Evaluation, the goal of the HFE analyst is to confirm that the

system design meets the Human Factors requirements defined in earlier acquisition phases. Additionally, the HFE analyst should attempt to identify new design or procedural issues that will have an adverse effect on the human in the system (Office of the Deputy Chief of Staff G1, 2005). If any such issues exist, the Human Systems Integration professional should determine if the deficiency can be sufficiently addressed through one of the other HSI domains. If no reasonable solution can be found through HSI domain trade-offs, then the system must revert to previous stages of the acquisition lifecycle to correct these deficiencies.

3. Specific Objectives of an HSI Human Factors Engineering Evaluation

- Influence system definition, design, and development by placing the capabilities and limitations of the target audience at the forefront of decision maker considerations (Department of Defense 2003; Malone and Miller 2003).
- Maximize the effectiveness of new systems by reducing required knowledge, skills and abilities; sensory, cognitive and physical workload; training; and mission critical error rates (Department of Defense, 2003; Malone and Miller, 2003; Department of Defense, 2004).
- Optimize the number of personnel required to safely operate the new system (Department of Defense, 2003).
- Ensure that system performance standards are not considered independently of humans in the loop (Office of the Deputy Chief of Staff G1, 2005).
- Determine key task and function requirements through a top down requirements analysis (Malone and Miller, 2003; Department of Defense, 2004).
- Reduce the time required to perform a task through increased reliability, accuracy, and ability to correct for errors (Malone and Miller, 2003).
- Optimize human-machine interfaces to improve safety, usability, reliability, survivability and time to respond (Malone and Miller, 2003).
- Influence workspace design and environment to improve habitability and maximize the number of people in the user population (Malone and Miller, 2003).
- Ensure technology and automation implementations do not degrade situational awareness by causing cognitive or sensory overload (Malone and Miller 2003).
- Ensure system design does not unduly impact timeliness and ability to conduct required maintenance tasks (Malone and Miller, 2003).
- Verify that the target audience is required to correctly operate the system to meet stated performance standards in all operational environments and conditions, including donning of personal protective equipment (Malone and Miller, 2003).

4. A Practical Human Factors Engineering Evaluation for REF Systems

Because the REF is primarily involved with NDI, COTS, and GOTS items, the ability of analysts to significantly influence the design of new products is limited. When conducting a Human Factors Engineering evaluation, the REF analysts typically find themselves in one of three possible situations: (1) evaluating a new sole source project, (2) evaluating a new product with multiple sourcing possibilities, or (3) re-evaluating a previous REF project prior to returning it to the field. Each of these situations presents a unique way for the REF to influence decisions involving product design and employment.

Clearly, the most restrictive of the situations above is when the REF analyst is evaluating a new sole source project because he or she is limited by time constraints to the product the contractor has to offer. In this situation, the REF analyst cannot have significant influence over the design of the project, and must make compensation for human factors concerns through the interaction with other domains. In order to make this happen, the REF must conduct an abbreviated TDRA to identify key functions and tasks the system must provide. With the key functions and tasks identified, the REF analyst can use the new system together with inputs from the Target Audience Description to accomplish these functions and tasks in order to begin making determinations on manpower, personnel and training levels required to meet the desired performance standard.

As an example, if the REF is evaluating a one-of-a-kind, low technology, 300-pound, man-portable piece of equipment, the Target Audience Description may imply that the system requires a three man heavy lift. In order to use this piece of equipment effectively, the system will require three dedicated people with specific biomechanical capabilities to move the system. This determination will affect the manpower and personnel domains, may have an impact on safety and survivability, and might convince the decision maker that the system is not feasible for the given concept of operations.

In the second possible scenario, a REF project may have multiple product sources. This situation is a little less restrictive to the REF analyst because while there is still no ability to make specific engineering design changes, the REF analyst might be able to

choose between alternatives from a user-centered perspective. In this situation, an abbreviated TDRA is conducted to develop key tasks and functions, and each alternative is evaluated using these key tasks and functions and the Target Audience Description. For example, if two products are being evaluated, a medium technology, 200 pound, man-portable piece of equipment and a high technology, 100 pound, man-portable piece of equipment, then the REF analyst can use applicable Human Factors standards to determine which piece of equipment best addresses the key functions and tasks. The true challenge of this situation is prioritizing the system requirements in order to optimize the trade-offs between HSI domains.

In the third possible scenario, the REF decides to re-offer a previously evaluated piece of equipment to other units in the field, using a spiral development mentality to offer performance improvements with each increment. The REF is able to offer specific design recommendations to be acted upon by the equipment designer. Although rare, this situation presents the best opportunity for the REF to tailor products to meet the requirements of Soldiers in the field.

As an example of this concept, consider a laser targeting system. In the first iteration, the REF analyst will be in situation one or two, where no input on system design is possible. If the product meets with immediate success in the field, the REF can use lessons learned to correct product deficiencies before sending subsequent iterations to the field. If the lessons learned can be gathered early enough then the time constraints that normally hamper design changes in such situations may be overcome.

This discussion of the HFE domain suggests several questions that the REF analyst could pose to evaluate the HFE domain (refer to the HFE portion of appendix A for questions).

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X. THE DATABASE

A. ABOUT THE HUMAN SYSTEMS INTEGRATION (HSI) ANALYSIS TOOL

The goal of ABRAHAM is to guide REF analysts and decision makers through the domains of HSI to determine where new products present unacceptable risks to operators, maintainers and support personnel. ABRAHAM provides up front, time sensitive, and mission oriented subjective analysis in the absence of objective data from product manufacturers and other organizations. Once a product has been fielded, ABRAHAM creates customizable surveys to elicit responses from Soldiers in the field about the suitability of the product.

ABRAHAM was implemented using Microsoft Access database software, which is a part of the Microsoft Office Professional software package. ABRAHAM makes extensive use of queries to convert user input into a tailored output of HSI domain questions for use in alternatives analysis and product evaluation. ABRAHAM also provides basic analysis of questionnaire responses and a written report, which addresses areas of concern for follow-on analysis by REF analysts and contracted Subject Matter Experts.

1. HSI Analysis Tool Structure

ABRAHAM's structure is depicted below (Figure 6). There are two main sections to ABRAHAM, the Alternatives Analysis (AoA) section and the Product Evaluation (PE) section. Each area of the tool is described with screenshots later in this chapter. The entire HSI Analysis Tool is designed to allow operation with minimal use of the Microsoft Access menu system.

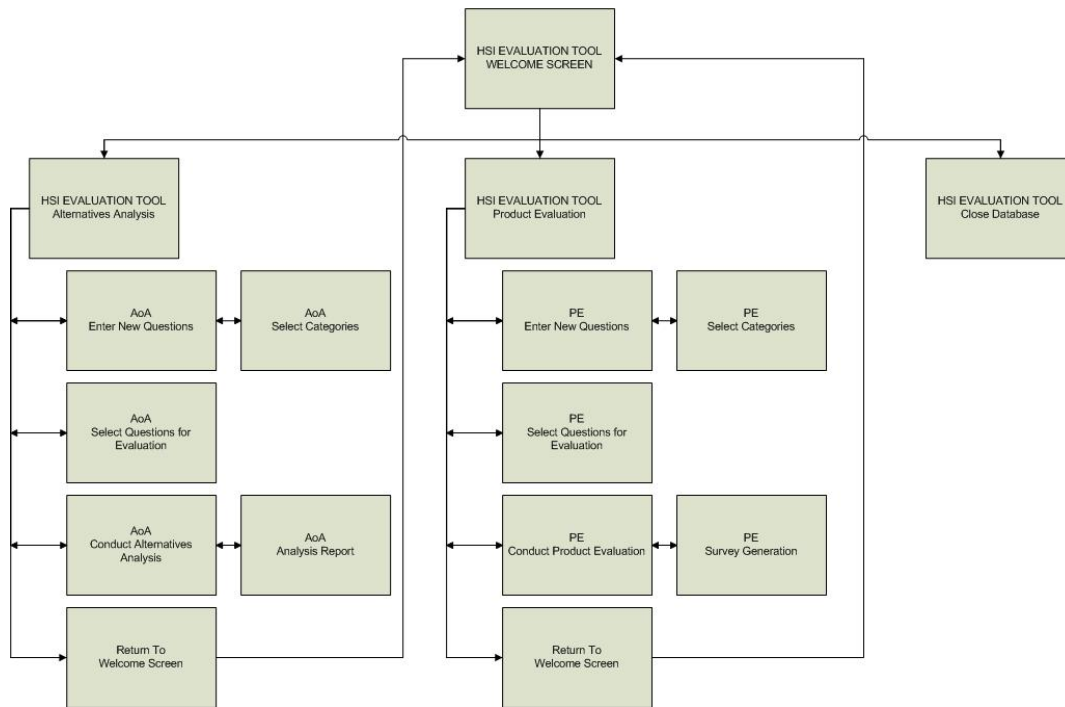


Figure 6. HSI Analysis Tool Structure

2. HSI Analysis Tool Installation

To install ABRAHAM, simply copy the HSI Questions Database.MDB file from the CD-ROM to any large storage device on your computer or network. ABRAHAM will require at least 20 megabytes of free space, and users should expect the file size to grow with continued use of the program. To keep the HSI Questions Database.MDB file at its minimum size, it is recommended that users routinely use the “Compact and Repair” tool by going to Tools\Database Utilities\Compact and Repair Database on the Access menu bar.

3. Opening ABRAHAM

To open ABRAHAM, double-click the mouse with the cursor on the HSI Questions Database.MDB file. When the file opens, the user may be prompted with a security warning that states the file may not be safe to open if it contains code intended to harm your computer (Figure 7).



Figure 7. Security Warning Page

This is a standard Microsoft warning when macro security level is set to medium and Access cannot verify that the file was created by a trusted source. For more information on this security warning, please use your Internet browser to go to the following link: <http://office.microsoft.com/en-us/access/HA011225981033.aspx#070>.

To eliminate this warning on your computer, please use your Internet browser to go to the following link:

<http://office.microsoft.com/en-us/access/HA011225981033.aspx#200>.

B. USING ABRAHAM

1. The Welcome Screen

Once the database file is opened, the user will be greeted with a welcome screen similar to the one depicted below (Figure 8). This Welcome screen will allow the user to enter the *Alternatives Analysis section*, the *Product Evaluation section*, or exit ABRAHAM. The user can use the Product Evaluation section independently of the Alternatives Analysis Section. By clicking the *Conduct Alternatives Analysis* button, the Alternatives Analysis Options page will open.

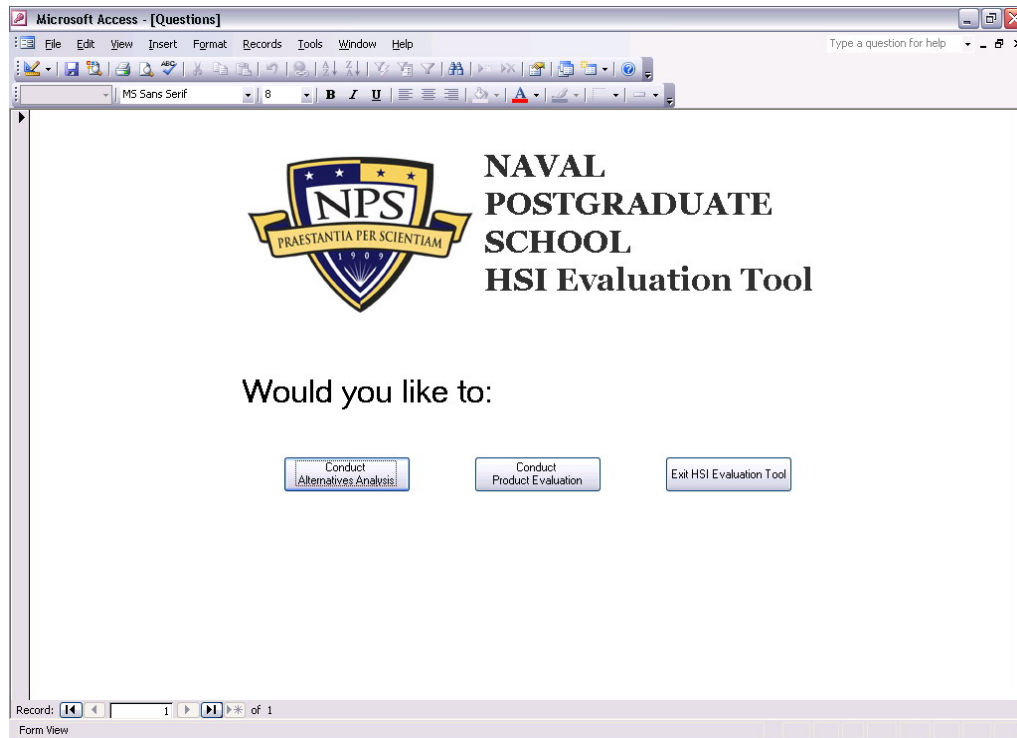


Figure 8. Welcome Screen

2. The Conduct Alternatives Analysis Options Page

The Alternatives Analysis Options page (Figure 9) will allow the user to *Enter New Questions*, *Select Questions for Evaluation*, *Conduct the Alternatives Analysis*, or *Return to the Welcome Screen*. The *Select Questions for Evaluation* button can be used independently of the *Enter New Questions* button, but the *Conduct Alternatives Analysis* is dependent on the entries made in the *Select Questions for Evaluation* page. By clicking the *Enter New Questions* button, the user will be taken to the *Alternatives Analysis Enter New Questions* page.

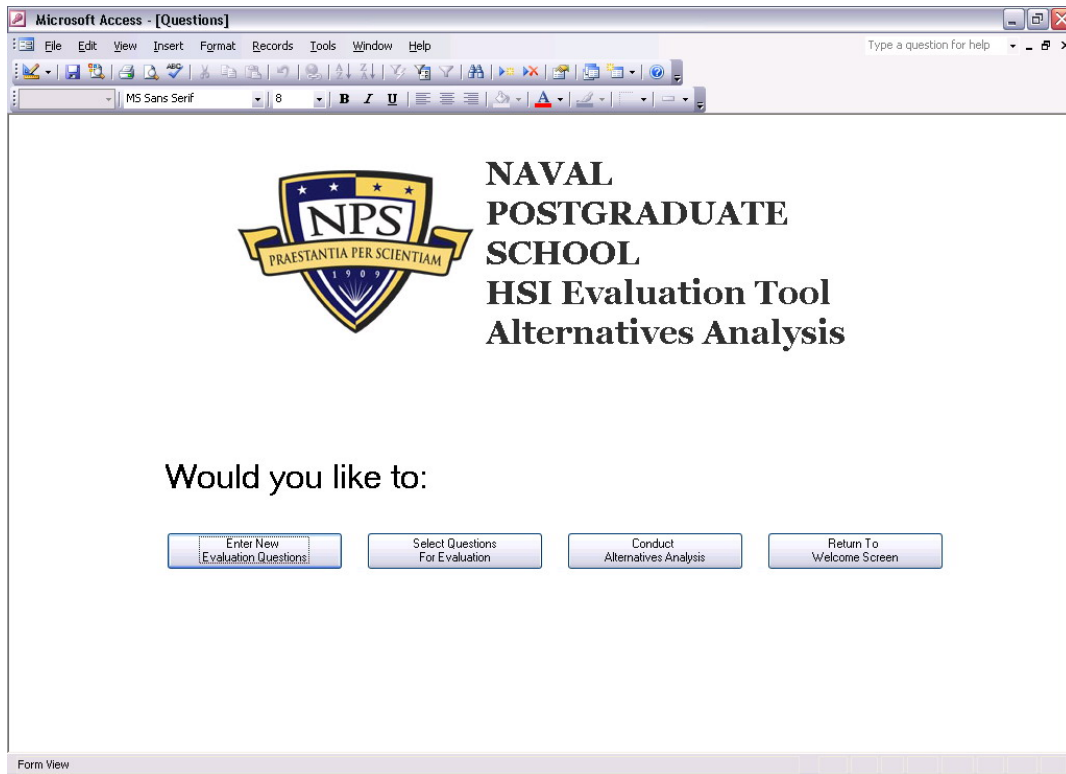


Figure 9. Alternatives Analysis Options Page

3. The Enter New Questions Page

The Enter New Questions Page (Figure 10) provides users to the ability add questions to the database. Users are not required to utilize this page, but this form may be useful if the user is examining a unique piece of equipment that is not addressed by the pre-loaded questions. The Enter New Questions is by far the most complicated form of ABRAHAM.

At the top of the Enter New Questions page, users will find a field for Question Key is *automatically filled in* by the database tool. The question key will not necessarily be in sequential order and will not match the record number shown on the bottom left side of the screen. The Question Key field is locked; users will not be allowed to change the question key.

The next field is the Question field, this is the field that the user will use to enter the new question. The Question field can be used to ask Likert scale, yes/no, and open-

ended questions. Users should remember to keep their questions as general as possible so that they can be applied to multiple system types.

To the right of the Question Field, the user will find two drop-down boxes. The first drop-down box allows the user to assign an HSI or DOTMLPF domain to the question. This field is not required, but it is useful because the questions will be grouped by these domains in later reports. The next drop-down box is use to assign the level of importance to the question. Users will have the option of assigning a value of high, medium, or low, and the value will be converted to a numerical score (high=3, medium=2, low=1) to be used as a multiplier to determine a final score for the system.

Figure 10. The Enter New Questions Page

Below the question field, the user will find two check boxes on the left side of the screen. The first check box asks the user if the question requires a Likert response. If unchecked then all fields below this question will be hidden. The second check box asks the user if a not applicable response is required for this question. If unchecked then the Likert Response N/A field will be hidden.

The Likert Responses are designed to support five responses. Likert Response 1 should always contain the *worst alternative*, while Likert Response 5 should contain the *most favorable alternative*. Using this format is *critical* to the program's logic, and the Alternative Analysis report will be flawed if the format is violated. When asking a yes/no type question, the negative response should be entered in Likert Response 1 and the positive response should be entered in Likert Response 5. For example, if the question asks "Is the system capable of causing serious bodily harm to the user?" then Likert Response 1 should be "Yes" and Likert Response 5 should be "No". Conversely, if the question asks "Does the system prevent targeting friendly units?" then Likert Response 1 should be "No" and Likert Response 5 should be "Yes".

Question scoring in the Alternatives Analysis Report is based on the Likert Response selected. Likert Response 1 is assigned 1 point, and Likert Response 5 is assigned 5 points. The Likert Response score is multiplied by the Importance multiplier to determine the maximum possible score for the question and the score earned for the question. For example, if a High importance question is answered with Likert Response 3 then the maximum score for the question will be 15 (Importance = 3 x 5 points for best alternative) and the question score will be 9 (Importance = 3 x 3 points for Likert Response 3). Likert Response N/A is given a score of zero and the maximum possible score will be assigned a value of zero.

In the center of the screen, the user is presented with two check boxes that ask if the question should be applied to the Alternatives Analysis Questionnaire or the Product Evaluation Questionnaire. One or both of these check boxes must be checked in order for the question to be included in later parts of the tool. If neither of these check boxes is selected then the question will not meet the criteria for inclusion the surveys generated by the tool.

Below these two check boxes, the user will find two buttons that are used to assign the question to certain product categories. If the user presses the *Select Individual Categories* button then the following screen will be opened (Figure 11). If the user presses the *Select All Categories* button then all the check boxes on the following page will be selected.

Microsoft Access - [Tbl-Questions]

File Edit View Insert Format Records Tools Window Help

Type a question for help

MS Sans Serif 8 B I U

What percentage of the target population is capable of understanding the training required to properly operate the new system?

- ☐ Ammunition and Fuses
- ☐ Antenna, Masts and Towers
- ☐ Army Combat Vehicles
- ☐ Artillery and Mortars
- ☐ Base or Camp Security
- ☐ Breaching Equipment
- ☐ Bridging Equipment
- ☐ C4ISR Equipment
- ☐ Camouflage Equipment
- ☐ Computing and Software
- ☐ Countermeasures
- ☐ Countercountermeasures
- ☐ Directed Energy Weapons
- ☐ Batteries and PowerSupplies
- ☐ EOD and Mine Clearance
- ☐ Explosives and Pyrotechnics
- ☐ Fire Control and Targeting
- ☐ Force Protection Systems
- ☐ Jamming Systems
- ☐ Medical and Survival Equipment
- ☐ Military and Special Vehicles
- ☐ Navigation Equipment
- ☐ Observation Equipment
- ☐ Personal Protective Equipment
- ☐ Reconnaissance and Measurement
- ☐ Personnel Shelters
- ☐ Target Tracking and Illumination
- ☐ Unmanned Aircraft
- ☐ Vehicle Ballistic Protection
- ☐ Other Systems

Check All Uncheck All Close Form

Form View FLTR

Figure 11. Product Categories Page

The user should select one or more categories by placing a check mark in the appropriate boxes. The buttons at the bottom of the screen allow the user to check or uncheck all categories, and the *Close Form* button will close the form and return the user to the Question Entry screen (Figure 10).

The final fields on the Question Entry form prompt the user for Question Source and Notes/Issues on the Question. The Question Source field is used to document the academic source of the question or the user who entered the question. The Notes/Issues on the Question field is an unlimited memo field used to document changes to the question or other issues considered during the life of the question.

On the bottom right of the page, the user will find buttons that allow for navigation through the question set. The button on the far left will return the first question and the next button will go backward one question. The button with the binocular image will open a search dialog box that will search the database based on the Question Key or Question field.

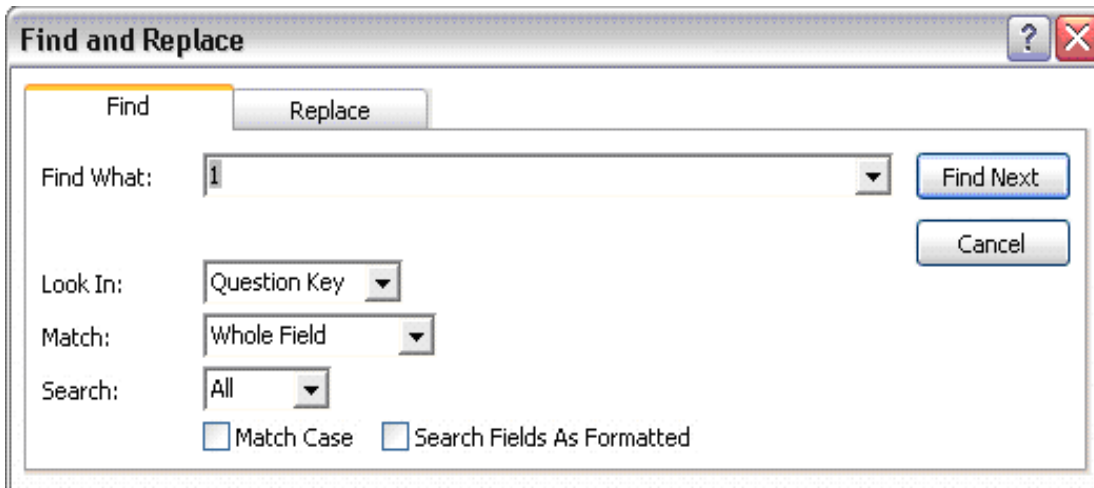


Figure 12. Find and Replace Screen

The button to the right of the Search button will advance the database by one question, and the next button will advance the database to the last question. The button with the image of a door will close the page and return the user to the *Alternatives Analysis Options* page (Figure 9).

4. The Select Questions for Evaluation Page

The second option on the Alternatives Analysis Options page is the *Select Questions for Evaluation* button. When the user selects this option, the following screen is opened (Figure 13). On this form, the user is presented with thirty systems categories and asked to select those categories that apply to the system being evaluated. As an example, if the user were evaluating a portable GPS system then the user might select *Navigation Equipment*, *Computing and Software*, and *Batteries and Power Supplies*.

On the bottom of the screen, there are two buttons for user input. Once the user has selected all applicable categories, pressing the *Get the Questions* button will allow the database to select the questions and return the user to the Alternatives Analysis Options Page (Figure 9). Pressing the *Close Form* button will close the form and return the user to the Alternatives Analysis Options page (Figure 9) *without* selecting any questions.

**NAVAL POSTGRADUATE SCHOOL
HSI Evaluation Tool
Alternatives Analysis**

Please place a check mark in each box that applies to your system.

<input type="checkbox"/> Ammunition and Fuses	<input type="checkbox"/> Countermeasures	<input type="checkbox"/> Military and Special Vehicles
<input type="checkbox"/> Antenna, Masts and Towers	<input type="checkbox"/> Countercountermeasures	<input type="checkbox"/> Navigation Equipment
<input type="checkbox"/> Army Combat Vehicles	<input type="checkbox"/> Directed Energy Weapons	<input type="checkbox"/> Observation Equipment
<input type="checkbox"/> Artillery and Mortars	<input type="checkbox"/> Batteries and PowerSupplies	<input type="checkbox"/> Personal Protective Equipment
<input type="checkbox"/> Base or Camp Security	<input type="checkbox"/> EOD and Mine Clearance	<input type="checkbox"/> Reconnaissance and Measurement
<input type="checkbox"/> Breaching Equipment	<input type="checkbox"/> Explosives and Pyrotechnics	<input type="checkbox"/> Personnel Shelters
<input type="checkbox"/> Bridging Equipment	<input type="checkbox"/> Fire Control and Targeting	<input type="checkbox"/> Target Tracking and Illumination
<input type="checkbox"/> C4ISR Equipment	<input type="checkbox"/> Force Protection Systems	<input type="checkbox"/> Unmanned Aircraft
<input type="checkbox"/> Camouflage Equipment	<input type="checkbox"/> Jamming Systems	<input type="checkbox"/> Vehicle Ballistic Protection
<input type="checkbox"/> Computing and Software	<input type="checkbox"/> Medical and Survival Equipment	<input checked="" type="checkbox"/> Other Systems

Get the Questions Close Form

Figure 13. Evaluation Tool Alternatives Page

5. The Conduct Alternatives Analysis Page

When the user selects the *Conduct Alternatives Analysis* button on the Alternatives Analysis Options page (Figure 9), the following screen will open (Figure 14). The questions on this page are based on the work done by the user on the Select Questions for Evaluation page. If the user skips the Select Questions for Evaluation page and opens this page directly then the program will generate a survey based on the last user's input on the Select Questions for Evaluation page.

When the Conduct Alternatives Analysis page opens (Figure 14), the user will be presented with a survey consisting of the questions in the database that are assigned to the Alternatives Analysis and meet the criteria established in the Select Questions for Evaluation page. The user should answer all questions as honestly as possible.

When all questions have been answered, the user should press the *Show HSI Analysis* button to conduct the analysis and show the HSI analysis report. Selecting the

Close Form button will close the form and return the user to the Alternatives Analysis Options Page (Figure 9) *without* displaying a report.

The screenshot shows a Microsoft Access window titled "Microsoft Access - [AoA Questionnaire]". The window contains a form titled "HSI EVALUATION TOOL Alternatives Analysis Questionnaire". The form has three main sections, each with a question, a set of five radio buttons, and a text box for additional feedback.

Section 1: Question: "To what extent will the user have an opportunity to practice with the equipment prior to using it in a true operational setting?". Radio buttons: "To no extent", "To a small extent", "To a moderate extent", "To a great extent", "To a very great extent". Feedback text box: "Would you like to leave additional feedback on this question?".

Section 2: Question: "To what extent is the training given to the troops valid for the task?". Radio buttons: "To no extent", "To a small extent", "To a moderate extent", "To a great extent", "To a very great extent". Feedback text box: "Would you like to leave additional feedback on this question?".

Section 3: Question: "To what extent is computer literacy required?". Radio buttons: "To no extent", "To a small extent", "To a moderate extent", "To a great extent", "To a very great extent". Feedback text box: "Would you like to leave additional feedback on this question?".

At the bottom right of the form, there are two buttons: "Show HSI Analysis" and "Close Form". The status bar at the bottom left indicates "Form View".

Figure 14. Alternatives Analysis Questionnaire Page

When the user presses the *Show HSI Analysis* button the following report will be generated in print preview mode (Figure 15). Pressing the Printer icon will send the report to the default printer. Pressing the Magnifying Glass icon will zoom in and out of the report. Pressing the Close button on the menu bar will close the report and return the user to the Conduct Alternatives Analysis page (Figure 9).

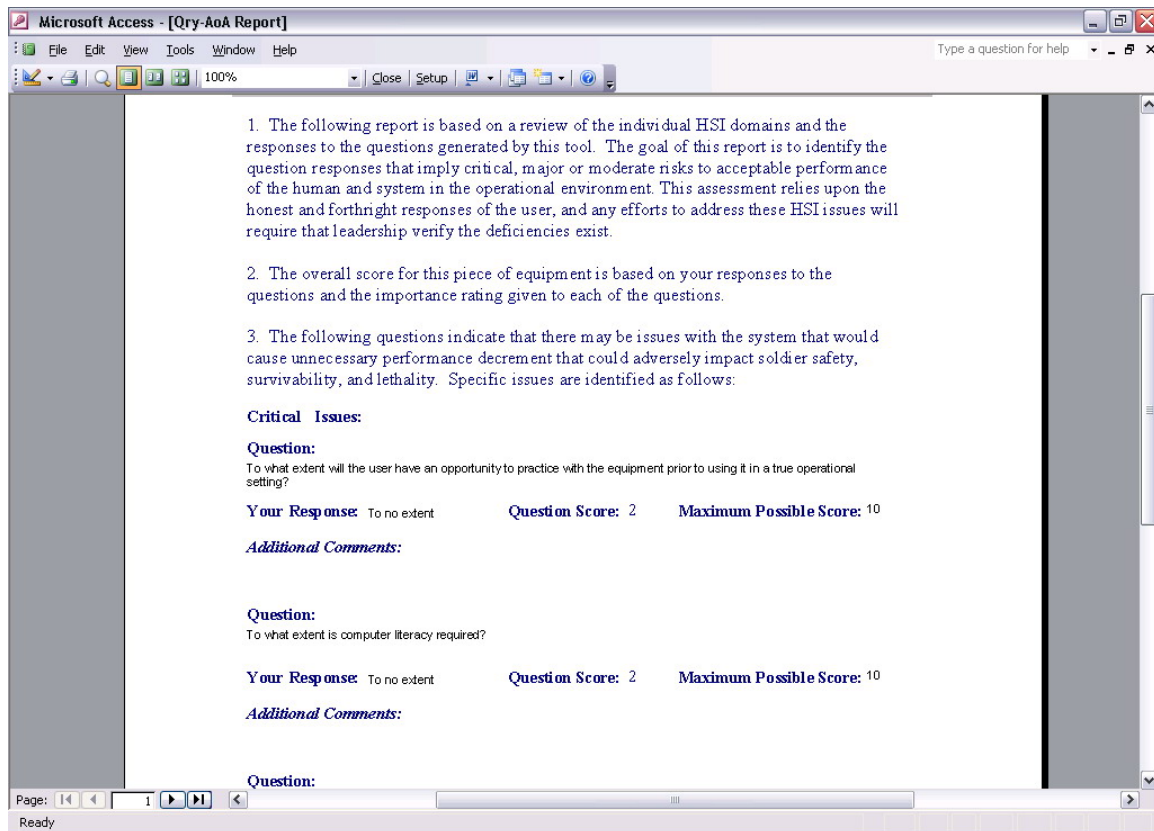


Figure 15. Results Evaluation Page

6. The Conduct Product Evaluation Options Page

On the Welcome Screen (Figure 16) the user can also open the Product Evaluation Options page by pressing the *Conduct Product Evaluation* button. The following is an example of the Product Evaluation Options page.

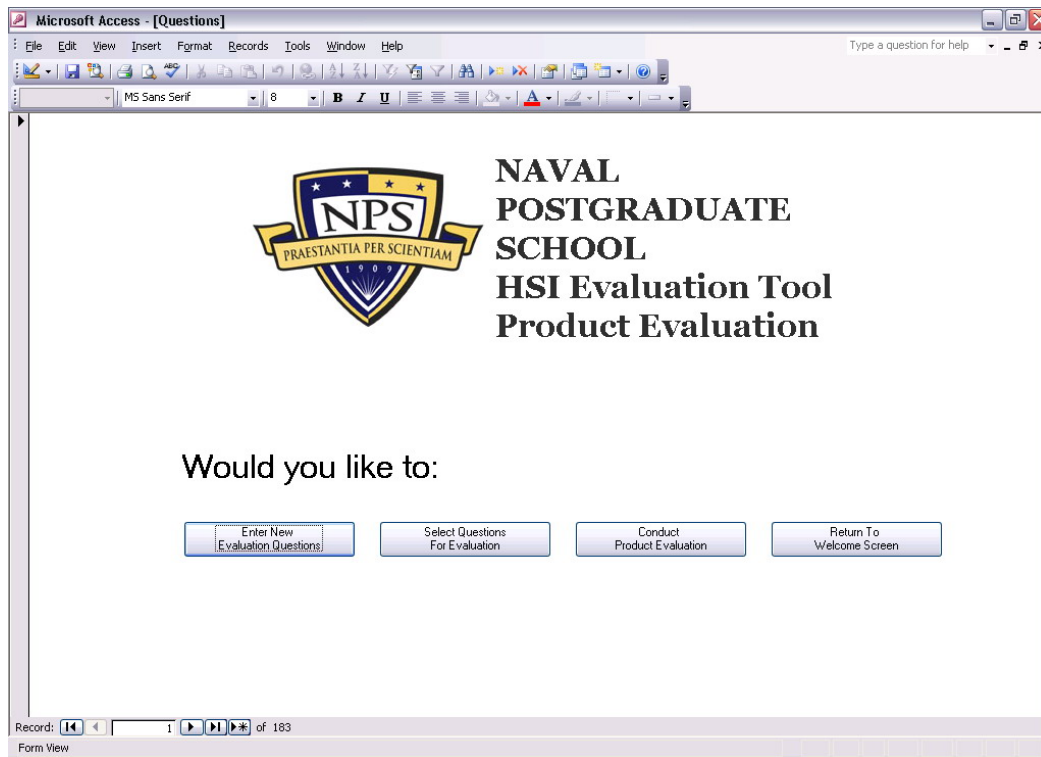


Figure 16. Product Evaluation Options Page

7. The Enter New Questions Page

The Enter New Questions Page (Figure 17) is an exact replica of the Enter New Questions Page (Figure 10) in the Alternatives Analysis section. The Enter New Questions page (Figure 17) is designed to allow users to add questions to the database for use in future analysis. Users are not required to utilize this page, but this form may be useful if the user is examining a unique piece of equipment that is not addressed by the pre-loaded questions. The Enter New Questions is by far the most complicated form of ABRAHAM.

At the top of the Enter New Questions page, users will find a field for Question Key is *automatically filled in* by the database tool. The question key will not necessarily be in sequential order and will not match the record number shown on the bottom left side of the screen. The Question Key field is locked and users will not be allowed to change the question key.

The next field is the Question field, and this is the field that the user will use to enter the new question. The Question field can be used to ask Likert scale, yes/no, and open-ended questions. Users should remember to keep their questions as general as possible so that they can be applied to multiple system types.

To the right of the Question Field, the user will find two drop-down boxes. The first drop-down box allows the user to assign an HSI or DOTMLPF domain to the question. This field is not required, but it is useful because the questions will be grouped by these domains in later reports. The next drop-down box is use to assign the level of importance to the question. Users will have the option of assigning a value of high, medium, or low, and the value will be converted to a numerical score (high=3, medium=2, low=1) to be used as a multiplier to determine a final score for the system.

The screenshot shows a Microsoft Access window titled "Microsoft Access - [Questions]". The form is titled "REF HSI Evaluation Tool" and includes the Naval Postgraduate School logo. The form contains the following fields and controls:

- Question:** A text field containing the question: "What percentage of the target population is capable of understanding the training required to properly operate the new system?"
- Question Key:** A locked text field.
- HSI/DOTMLPF Domain:** A drop-down menu with "Training" selected.
- Level of Importance of this question:** A drop-down menu with "High" selected.
- Question Source:** A text field.
- Is this a Likert Scale Question?:** A checked checkbox.
- Is an N/A response required?:** A checked checkbox.
- Likert Response 1 (low side):** A text field with "up to 20%".
- Likert Response 2:** A text field with "21% - 40%".
- Likert Response 3:** A text field with "41% - 60%".
- Likert Response 4:** A text field with "61% - 80%".
- Likert Response 5:** A text field with "81% - 100%".
- Likert Response N/A:** A text field with "Not Applicable".
- To which Questionnaire does this question apply?:** A list box with "Analysis of Alternatives" and "Fielded Product Evaluation", both checked.
- To which Systems should I apply this question?:** Two buttons: "Select Individual Categories" and "Select All Categories".
- Notes/Issues on the Question:** A text area containing the note: "Question reworked. The original question was Does the training system accommodate 'the central 50 percent of the male and female population?'".

At the bottom, there is a status bar showing "Record: 1 of 183" and "Question Key Number for Database Efficiency."

Figure 17. Enter New Questions Page

Below the question field, the user will find two check boxes on the left side of the screen. The first check box asks the user if the question requires a Likert response. If unchecked then all fields below this question will be hidden. The second check box asks the user if a not applicable response is required for this question. If unchecked then the Likert Response N/A field will be hidden.

The Likert Responses are designed to support five responses. Likert Response 1 should always contain the *worst alternative*, while Likert Response 5 should contain the *most favorable alternative*. Using this format is *critical* to the program's logic, and the Alternative Analysis report will be flawed if the format is violated. When asking a yes/no type question, the negative response should be entered in Likert Response 1 and the positive response should be entered in Likert Response 5. For example, if the question asks "Is the system capable of causing serious bodily harm to the user?" then Likert Response 1 should be "Yes" and Likert Response 5 should be "No". Conversely, if the question asks "Does the system prevent targeting friendly units?" then Likert Response 1 should be "No" and Likert Response 5 should be "Yes".

In the center of the screen, the user is presented with two check boxes that ask if the question should be applied to the Alternatives Analysis Questionnaire or the Product Evaluation Questionnaire. One or both of these check boxes must be checked in order for the question to be included in later parts of the tool. If neither of these check boxes is selected then the question will not meet the criteria for inclusion the surveys generated by the tool.

Below these two check boxes, the user will find two buttons that are used to assign the question to certain product categories. If the user presses the *Select Individual Categories* button then the following screen will be opened (Figure 18). If the user presses the *Select All Categories* button then all the check boxes on the following page will be selected.

Microsoft Access - [Tbl-Questions]

Type a question for help

What percentage of the target population is capable of understanding the training required to properly operate the new system?

<input type="checkbox"/> Ammunition and Fuses	<input type="checkbox"/> Explosives and Pyrotechnics
<input type="checkbox"/> Antenna, Masts and Towers	<input type="checkbox"/> Fire Control and Targeting
<input type="checkbox"/> Army Combat Vehicles	<input type="checkbox"/> Force Protection Systems
<input type="checkbox"/> Artillery and Mortars	<input type="checkbox"/> Jamming Systems
<input type="checkbox"/> Base or Camp Security	<input type="checkbox"/> Medical and Survival Equipment
<input type="checkbox"/> Breaching Equipment	<input type="checkbox"/> Military and Special Vehicles
<input type="checkbox"/> Bridging Equipment	<input type="checkbox"/> Navigation Equipment
<input type="checkbox"/> C4ISR Equipment	<input type="checkbox"/> Observation Equipment
<input type="checkbox"/> Camouflage Equipment	<input type="checkbox"/> Personal Protective Equipment
<input type="checkbox"/> Computing and Software	<input type="checkbox"/> Reconnaissance and Measurement
<input type="checkbox"/> Countermeasures	<input type="checkbox"/> Personnel Shelters
<input type="checkbox"/> Countercountermeasures	<input type="checkbox"/> Target Tracking and Illumination
<input type="checkbox"/> Directed Energy Weapons	<input type="checkbox"/> Unmanned Aircraft
<input type="checkbox"/> Batteries and Power Supplies	<input type="checkbox"/> Vehicle Ballistic Protection
<input type="checkbox"/> EOD and Mine Clearance	<input type="checkbox"/> Other Systems

Check All Uncheck All Close Form

Form View FLTR

Figure 18. Product Categories Page

The user should select one or more categories by placing a check mark in the appropriate boxes. The buttons at the bottom of the screen allow the user to check or uncheck all categories, and the *Close Form* button will close the form and return the user to the Question Entry screen (Figure 17).

The final fields on the Question Entry form prompt the user for Question Source and Notes/Issues on the Question. The Question Source field is used to document the academic source of the question or the user who entered the question. The Notes/Issues on the Question field is an unlimited memo field used to document changes to the question or other issues considered during the life of the question.

On the bottom right of the page, the user will find navigation buttons. The button on the far left will return to the first question and the next button will go backward one question. The button with the binocular image will open a search dialog box that will search the database based on the Question Key or Question field.

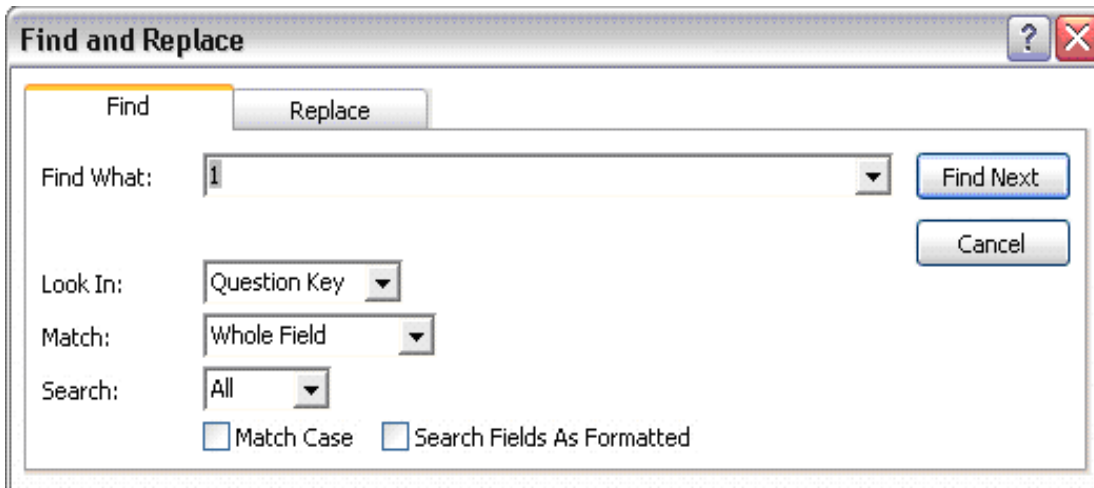


Figure 19. Find and Replace Screen

The button to the right of the Search button will advance the database by one question, and the next button will advance the database to the last question. The button with the image of a door will close the page and return the user to the Product Evaluation Options page (Figure 18).

8. The Select Questions for Evaluation Page

The second option on the Product Evaluation Options page is the *Select Questions for Evaluation* button. Again, this page is an exact replica of the Select Questions for Evaluation page in the Alternatives Analysis section. When the user selects this option, the following screen is opened. On this form, the user is presented with thirty systems categories and asked to select those categories that apply to the system being evaluated. As an example, if the user were evaluating a portable GPS system, then the user might select *Navigation Equipment*, *Computing and Software*, and *Batteries and Power Supplies*.

On the bottom of the screen, there are two buttons for user input. Once the user has selected all applicable categories, pressing the *Get the Questions* button will allow the database to select the questions and return the user to the Product Evaluation Options Page. Pressing the Close Form button will close the form and return the user to the Product Evaluation Options page *without* selecting any questions.

NAVAL POSTGRADUATE SCHOOL HSI Evaluation Tool Product Evaluation

Please place a check mark in each box that applies to your system.

<input type="checkbox"/> Ammunition and Fuses	<input type="checkbox"/> Countermeasures	<input type="checkbox"/> Military and Special Vehicles
<input type="checkbox"/> Antenna, Masts and Towers	<input type="checkbox"/> Countercountermeasures	<input type="checkbox"/> Navigation Equipment
<input type="checkbox"/> Army Combat Vehicles	<input type="checkbox"/> Directed Energy Weapons	<input type="checkbox"/> Observation Equipment
<input type="checkbox"/> Artillery and Mortars	<input type="checkbox"/> Batteries and PowerSupplies	<input type="checkbox"/> Personal Protective Equipment
<input type="checkbox"/> Base or Camp Security	<input type="checkbox"/> EOD and Mine Clearance	<input type="checkbox"/> Reconnaissance and Measurement
<input type="checkbox"/> Breaching Equipment	<input type="checkbox"/> Explosives and Pyrotechnics	<input type="checkbox"/> Personnel Shelters
<input type="checkbox"/> Bridging Equipment	<input type="checkbox"/> Fire Control and Targeting	<input type="checkbox"/> Target Tracking and Illumination
<input type="checkbox"/> C4ISR Equipment	<input type="checkbox"/> Force Protection Systems	<input type="checkbox"/> Unmanned Aircraft
<input type="checkbox"/> Camouflage Equipment	<input type="checkbox"/> Jamming Systems	<input type="checkbox"/> Vehicle Ballistic Protection
<input type="checkbox"/> Computing and Software	<input type="checkbox"/> Medical and Survival Equipment	<input checked="" type="checkbox"/> Other Systems

[Get the Questions] [Close Form]

Record: 1 of 1
Form View

Figure 20. Questions for Evaluation Page

9. The Conduct Product Evaluation Page

When the user selects the *Conduct Product Evaluation* button on the Product Evaluation Options page (Figure 16), the following screen will open (Figure 21). The questions on this page are based on the work done by the user on the Select Questions for Evaluation page. If the user skips the Select Questions for Evaluation page and opens this page directly then the program will generate a survey based on the last user's input on the Select Questions for Evaluation page.

When the Conduct Product Evaluation page opens (Figure 21), the user will be presented with a list of questions with a single check box located to the right of the question. The user should read each question and place a check mark next to each question that should be included in the final survey. The list of questions on this form consists of the questions assigned to the Product Evaluation section that meet the criteria established in the Select Questions for Evaluation page.

When all questions have been selected, the user should press the *Generate Survey* button to create the survey to be forwarded to the personnel in the field. Selecting the *Close Form* button will close the form and return the user to the Product Evaluation Options Page *without* displaying a report.

The screenshot shows a Microsoft Access window titled "Microsoft Access - [Evaluation Questionnaire]". The main form is titled "HSI EVALUATION TOOL" and "Select Questions for Product Evaluation Questionnaire". Below the title, it says "Select all Questions to be applied to the survey." The form contains five questions, each with a checkbox and a list of response options:

- ☐ **What percentage of the target population is capable of understanding the training required to properly operate the new system?**
Options: up to 20%, 21% - 40%, 41% - 60%, 61% - 80%, 81% - 100%, Not Applicable
- ☐ **To what extent can Government and contractor personnel be trained to complete all system-related tasks?**
Options: To no extent, To a small extent, To a moderate extent, To a great extent, To a very great extent
- ☐ **How effectively does the training system enable soldiers to complete currently assigned duties?**
Options: Very ineffective, Ineffective, Neither ineffective nor effective, Effective, Very effective
- ☐ **To what extent do the system design characteristics exceed cognitive abilities of the target audience?**
Options: To a very great extent, To a great extent, To a moderate extent, To a small extent, To no extent
- ☐ **To what extent have the system's critical tasks been identified for operators?**
Options: To no extent, To a small extent, To a moderate extent, To a great extent, To a very great extent

At the bottom right of the form, there are two buttons: "Generate Survey" and "Close Form". The status bar at the bottom left indicates "Form View".

Figure 21. Conduct Product Evaluation Page

When the user presses the *Generate Survey* button the following report will be generated in print preview mode. Pressing the Printer icon will send the report to the default printer. Pressing the Magnifying Glass icon will zoom in and out of the report. Pressing the Close button on the menu bar will close the report and return the user to the Conduct Alternatives Analysis page (Figure 16).

Microsoft Access - [Tbl-Evaluation Questionnaire]

File Edit View Tools Window Help

Type a question for help

100%

Close Setup

REF Product Evaluation Questionnaire

Do you have any issues with your ability to wear/ use this system with existing gear?

no issues small issues but e noticeable issue, big issues, hard t prevents from doi

Does this system change the way you wear your gear?

no issues small issues but e noticeable issue, big issues, hard t prevents from doi

To what extent do the system design characteristics exceed cognitive abilities of the target audience?

To a very great To a great extent To a moderate ex To a small extent To no extent

To what extent can Government and contractor personnel be trained to complete all system-related tasks?

To no extent To a small extent To a moderate ex To a great extent To a very great e

To what extent have the system's critical tasks been identified for operators?

To no extent To a small extent To a moderate ex To a great extent To a very great e

How effectively does the training system enable soldiers to complete currently assigned duties?

Very ineffective Ineffective Neither ineffective Effective Very effective

What percentage of the target population is capable of understanding the training required to properly operate the new system?

up to 20% 21% - 40% 41% - 60% 61% - 80% 81% - 100% Not Applicable

Page: 14 1

Ready

Figure 22. Product Evaluation Questionnaire

10. The Exit the HSI Evaluation Tool Button

Pressing the Exit the HSI Evaluation Tool button on the Welcome Screen will close ABRAHAM.

XI. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

The Discussion, Conclusions and Recommendations chapter begins with a discussion of conceptual (the question base) and technical (the database) challenges the authors faced during the development of ABRAHAM. Following the discussion of the HSI Analysis Tool development issues, the authors present the feedback obtained during the demonstration sessions at the HFE-TAG, the REF, and the Marine Corps Operational Test and Evaluation Activity (MCOTEA). Finally, the authors summarize the work completed to date, comment on the degree to which ABRAHAM addresses the Effective Need Statement, and conclude with recommendations for future work to improve the tool.

A. DISCUSSION

During the development of ABRAHAM, the authors identified issues related to the tool's concept and development. This section explains how the issues influenced the design and implementation of the tool, and how the authors decided to address these concerns in the current iteration. Unless these issues are appropriately addressed in future iterations of ABRAHAM, there will be significant threats to its widespread acceptance and use.

1. Development of ABRAHAM

a. Conceptual Issues

During the development of ABRAHAM, the authors identified three conceptual issues that resulted in significant repercussions for the project's success. Specifically, the authors found the variety of system types and lack of doctrine made it difficult to adopt rules for question implementation and scoring systems. Additionally, the authors struggled to define a meaningful scoring system that evaluated the HSI domains and presented the decision maker with a useful recommendation. Finally, the general language used to apply the questions to multiple categories or multiple systems within a category gives rise to reliability and validity concerns for the questionnaires generated by the tool. A more thorough discussion of these conceptual issues follows. The challenge in creating a tool that, by definition, is so general in nature that it can be

applied to multiple systems is that the governing rules for the tool must also be fairly general. Most surveys are designed to evaluate a specific piece of equipment for a specific use in a well defined environment, for example, a home stereo system used to project surround sound in a home entertainment room. In this scenario, it is relatively easy for the author to design the survey based on the equipment and environment and analyze the responses based on a shared understanding of the environment between author and respondent. To ensure this shared understanding, the author can generate very specific questions that leave little room for misinterpretation.

Using ABRAHAM to create surveys that leverage shared understanding between REF analyst and respondents is difficult because there is a vast number of the combinations of product and doctrine that could be evaluated. For example, a survey question designed to ascertain the responsiveness of an unmanned aerial vehicle could mean availability to Soldiers on reconnaissance missions in Iraq and simple flight worthiness to the Soldiers controlling the aircraft in high altitude environments in Afghanistan. The authors were unable to identify a method within the tool to establish a rule set that could be used to better define all system and doctrine combinations. As a result, ABRAHAM requires the REF analyst and survey respondents maintain strict adherence to the REF 10-Liner and other requirements documents as the underlying basis for evaluating questions. If this method is not properly managed then it can result in inconsistent responses that may challenge the reliability and validity of the survey instrument. This issue is the primary challenge in implementing the tool, and must be reconsidered in any future implementation of this database.

The second conceptual challenge faced was developing a scoring system that provided the REF analysts and decision makers with a “so what” statement at the end of the analysis. The authors made allowances for the REF analysts not being fully trained HSI specialists, and decided, that although ABRAHAM needed to provide a list of the HSI issues identified for the system, some easy to understand indication of the “HSI worthiness” was also needed. The authors considered a points system and a traffic light system (red, yellow, green) as alternatives for the indicator, but quickly discovered that there was no standard upon which to base this recommendation. In a commercial situation, it may prove useful to “red light” a system that has as little as one deficiency,

but for the REF, the same one deficiency may mean little in light of the consequences of not fielding the equipment. For example, even if the REF's Packbot exceeded multiple military or OSHA lift standards, it may be far better to field the equipment with its deficiencies than continue to let Soldiers prosecute improvised explosive devices by hand. ABRAHAM is clearly incapable of understanding the consequences of each situation, and the use of a traffic light or other scoring methodology within the tool may prove meaningless if most of the fielded REF products are scored in the "red light" or low score range. As discussed in the Instruction Manual chapter, in the current implementation, a percentage of the maximum total score is the method used to convey the measure of "HSI worthiness".

The third major conceptual issue faced during development of the tool centered on the reliability and validity of the surveys generated by the tool. As discussed above, there are many challenges to creating a shared understanding of system and doctrine between the REF analyst and operators, maintainers, and supporters in the field. Without the shared understanding of the questions and what the survey is asking, there should be little expectation that the survey is generating the information it was designed to extract. Clearly, the validity of ABRAHAM can be challenged, and if the survey is without validity then all reliability issues are moot.

Unfortunately, even if the survey instrument generated by ABRAHAM is valid, the Alternatives Analysis questionnaire is based on each analyst's understanding at the time of survey completion. The authors have little expectation for inter-rater and test-retest reliability because each respondent's understanding of the system will change as they learn more about the system, doctrine, environment and interactions between these variables. REF decision makers must remember that the Alternatives Analysis section of HSI Analysis Tool was designed to identify potential HSI risks the system could pose to Soldiers and not as a stand alone decision support aid.

b. Question Development Issues

The power of ABRAHAM resides in its ability to assist REF analysts (with little or no HSI expertise) to conduct comprehensive HSI evaluations of proposed systems. While the development of the HSI question base should have been the easiest

part of the overall tool development, several issues related to question development arose during the project that limited the variety of questions included in the database. A brief discussion follows describing these issues, including consideration for the types of questions, the content of the questions, and the challenges with the response range.

In the current implementation, ABRAHAM allows respondents to answer questions using closed-ended answers for analysis and open-ended answers for additional commentary. As discussed in the Instruction Manual chapter, the methodology for scoring each question was based on assigning a score to each Likert response option in order to later identify areas of unacceptable risk. This scoring method allows for Likert scale questions with ordered responses, where each response can be graded in relation to the other responses, but not categorical responses. For example, ABRAHAM is designed to analyze a question in which the response measures are “up to 20%”, “21% to 40%”, “41% to 60%”, “61% to 80%”, and “81% to 100%”, but the tool is not designed to analyze a question in which the response measures do not imply value, such as the demographic responses of “African American”, “Asian/Pacific Islander”, “Caucasian”, “Hispanic”, or “Other”. ABRAHAM is capable of analyzing binary questions as a subset of the five point Likert scale, but it is not capable of understanding ordinal responses in which respondents are asked to rank a set of options. ABRAHAM is also incapable of analyzing Constant Sum responses, Stapel Scale responses, Semantic Differential Scale responses, and Multiple Choice responses. Open-ended responses are provided to allow respondents to convey additional information, but these responses are not automatically scored by ABRAHAM.

As the authors began developing the question base, it quickly became apparent that two categories of questions were needed to fully address Alternatives Analysis and Product Evaluation. Although there were some questions that applied to both questionnaires, Alternatives Analysis questions tended to compare equipment specifications to HSI domain standards while Product Evaluation Questions tended to query the usability, reliability, maintainability, and other “ilities” (<http://www.answers.com/topic/ilities>) related to the equipment and its training systems. Alternatives Analysis questions were generated from the knowledge gathered from the

HSI domain literature reviews and input from SMEs. Product Evaluation questions were derived from SME input, general experience, and previous Army surveys and questionnaires.

The final issue with question development concerns the possible range of responses that may be required in the Product Evaluation questions. For example, if the database contains a question that assesses the accuracy of a weapon system, a response scale measured in millimeters may be appropriate for a rifle but completely inadequate for long-range artillery. The current implementation of ABRAHAM requires a separate question if the response requires a different scale. This issue raises a concern because it can slow the analysis process and dissuade the REF analysts from using the tool.

c. Database Development Issues

There were three programmatic challenges that limited overall functionality of the first implementation of ABRAHAM's database and may prove difficult to address in future iterations of program. The most critical database issue the authors faced was the inability to dynamically build new tables to store responses to the Product Evaluation Questionnaire. Secondly, the authors could not develop an acceptable methodology for limiting the total number of questions in the Alternatives Analysis and, therefore to limit the total time required to complete the survey while also meeting the goal of providing a comprehensive analysis of all HSI domains. Finally, the authors were unable to develop a method of storing the queries that were used to generate the surveys for future use by REF analysts. These issues will now be covered in greater depth.

When developing a new table to store data in Microsoft Access, the program requires that the programmer define the dimensions of the table. In Access, the programmer must specify the number of columns (fields) and define the type of information each column will contain. The number of rows (records) can number in the thousands and does not have to be specified when the table is first designed. The challenge with ABRAHAM is that the number of questions in each survey is variable. Additionally, for each piece of equipment to be evaluated, the numbers of respondents to each survey can be variable. Ideally, the REF analyst should be able to generate a new

table to store survey responses at the click of a button, but there is no provision for this in the current iteration of ABRAHAM. Without the ability to dynamically create this new table, ABRAHAM is unable to store Product Evaluation responses and cannot be used to compute the summary and descriptive statistics that would provide insight into the product's performance in the field. Although the ideal solution would be to develop a "push button" method previously discussed for a variable number of fields, one other possible solution would be to limit all surveys to a specific number of questions or a specific number of respondents to allow for pre-programming of ABRAHAM to create the appropriate tables to save the data at the push of a button.

As the question base of ABRAHAM grows, the program must strike a balance between limiting the number of questions asked in order to meet REF time constraints and asking enough questions to provide a sufficient look at the HSI decision space. In the Product Evaluation section of ABRAHAM, the REF analyst serves as a filter to limit the final questionnaire to select only those questions that are most applicable to the Soldiers in the field. In the Alternatives Analysis section of ABRAHAM, the REF analyst is presented with all questions (based on the choices selected on the Questions for Evaluation page) because there is currently no computer-based filter to limit the number of questions asked. While there is no technological limitation that would require a limitation on the number of questions asked, it is generally infeasible for the REF analyst to spend more than a few hours on these surveys. During database development, the authors discussed methods for limiting the number of questions, including a simple random sampling of the question base, a stratified random sampling of the question base based on question importance and HSI domain, and a method of selecting all high importance questions and a percentage of lower importance questions to arrive at a predetermined number of questions. The current version of ABRAHAM does not implement any of these filtering schemes because the authors felt it was important to identify HSI concerns using an unfiltered system, especially with the question base in its infancy.

The final major challenge faced in development of ABRAHAM was establishing the ability to save the database queries used to generate the Alternatives Analysis and Product Evaluation surveys. ABRAHAM currently uses the Microsoft

Query by Form methodology to provide an intuitive interface for tool users, but there is no method in place to save this input. Without the ability to save the database queries, the REF analyst cannot recall a survey to reevaluate a piece of equipment, especially if a random sampling filter is employed to limit the number of questions. This is especially troublesome if the REF analyst wants to use a previously created survey to evaluate a second or subsequent iteration of a piece of equipment to determine if changes to the system were beneficial.

Once software development reached a level that allowed for the basic operation of the module, the authors arranged demonstrations with the REF and other HSI domain experts to garner feedback and determine the initial response to the tool. The following section discusses the authors' reasons for selecting the demonstration venues, a description of the demonstration at each venue, and a discussion of the feedback obtained at each presentation.

2. HSI Analysis Tool Demonstration

The ABRAHAM prototype was demonstrated in three separate venues within a two week time period from 6 – 20 November 2006. The authors selected the DoD Human Factors Engineering Technical Advisory Group (HFE TAG), the REF, and the USMC Operational Test and Evaluation Activity because these sites provided access to HSI practitioners who had a broad range of expertise within each of the domains of HSI and/or who understood the needs of customer activities. Since HSI is a relatively new field and one that represents an integration of various established fields, HSI-focused projects must incorporate each domain. Without fair representation of each domain in the database, optimization is less likely. A second reason for selecting three demonstration venues was that acceptance from more than one venue validated the proof of concept and helped to ensure the database's utility. Demonstrating the tool to just the REF would possibly have resulted in a tool that was too specific to the REF and its current processes. By gathering diverse input, the authors were able to shape ABRAHAM to meet the REF's need while remaining generalized enough to support other organizations that expressed an interest in the methodology. The authors felt this characteristic of ABRAHAM was essential, given recent efforts and guidance for the services within DoD to adapt a joint prospective.

a. The HFE TAG Demonstration Session

The first presentation of the database was at the HFE TAG conference located in Monterey, California on 6 November 2006. This presentation was an informal poster session and demonstration of ABRAHAM's concept and contents. The audience included Human Factors Engineering and HSI experts. During this time, experts were able to provide the authors with additional information as well as view a demonstration of ABRAHAM. Throughout the two hour demonstration period, small groups were provided with a walkthrough of the tool. In sum, the demonstration was given approximately 12 times to audiences that represented the U.S. Army, U.S. Air Force, U.S. Navy, U.S. Marine Corps, Canadian military services, and civilian contractors.

Overall, feedback from domain experts was extremely positive. Specifically, experts' comments demonstrated support for the database's concept, design, content, and abilities. Domain experts were pleased with the customized literature review that was tailored to rapid acquisition and the REF. Concerns were limited to the database's possible growth and transition into the traditional acquisition field. Specifically, the attempt to generalize questions to capture the broad domains of HSI has not always rendered usable results or tools.

b. Presentation to the Rapid Equipping Force

As mentioned previously, the primary customer of ABRAHAM was the Army's Rapid Equipping Force. The authors traveled to Fort Belvoir, Virginia to present the current state of the research to the REF 20 November 2006. The purpose of this meeting was threefold. First, the authors wanted to ensure that the database's concept and contents met the customer's needs and desires. Second, the authors wanted to obtain customer's feedback for necessary modifications and product improvement. Finally, at the conclusion of the meeting, the authors sought agreement with the REF on the next steps that should be taken.

The REF meeting began with introduction of all attendees, which included::

- John Geddes, Director, Technology Management Director
- LTC William Garland, General Support Product Manager
- Joe Rozmeski, Deputy, Operations

- Scott Torgerson, Capabilities & Assessments Team Lead
- Betty Maguder, Assessment Analyst
- MAJ Bob Lentz, Assessment Analyst

The presentation began with a discussion of the researchers' backgrounds, a description of HSI, and a discussion of how HSI should apply to the REF's overall analysis methodology. Once the presentation was completed, the ABRAHAM demonstration began and open discussion was welcomed. The following four paragraphs highlight the REF's primary concerns and feedback.

The REF expressed great satisfaction with ABRAHAM's intuitive user interface and easy-to-understand navigation aids. The REF expressed a great deal of satisfaction with the ease with which the Product Evaluation section was able to generate tailored surveys and liked the ability to exclude any question on the survey that was inappropriate for the system. Although the REF analysts were equally pleased with the Alternatives Analysis section of the tool, questions were raised about the sensitivity and utility of the scoring system. Suggested areas of improvement included: the refinement of the product categories to more closely match REF projects; a method to generate separate Product Evaluation surveys for operators, maintainers, and supervisors; and an ability to distribute surveys via personal digital assistant (PDA) or via the Internet.

The REF recommended two major improvements to ABRAHAM that if incorporated, would greatly improve the analysis capabilities of the command. The first recommendation involved having the HSI tool automatically compute summary and descriptive statistics for Product Evaluation that could be used in briefs and reports provided to decision makers. The second recommendation involves implementing ABRAHAM in a networked environment to allow analysts to share a common question base and leverage the combined knowledge of all analysts to grow and mature the tool.

As previously discussed, employing a statistical analysis algorithm in ABRAHAM is technically feasible, but implementing this feature under the current iteration of the tool would require a major break in the user interface to define the dimensions of the table that would store the data. The authors recommended that REF

analysts employ a commercially available statistical analysis package such as SPSS, S-Plus, or SAS until the feature can be implemented in ABRAHAM.

The current iteration of ABRAHAM was not designed to support user accounts and other network specific applications, but the tool can be employed in a multi-user environment as coded with the caveat that no two users could have the same question record (row of a table) open at a time. Microsoft Access is capable of limited employment in a networked, multi-user environment, but the program can become unreliable as the number of users increase. A more complete discussion of multi-user database environments is included in the Conclusion section of this chapter.

c. Presentation to MCOTEA

The final presentation was conducted at MCOTEA at Quantico, Virginia, on 20 November 2006. This presentation was conducted in response to the Marine Corp's request for a more robust HSI questionnaire database that would accommodate their test and evaluation methodology. Similar to the presentation given to the REF, the presentation commenced with a discussion about the researchers' backgrounds and a description of HSI, which included the importance of HSI and how HSI fits into the MCOTEA's overall methodology of analyses.

Feedback from MCOTEA focused on the differences in language and terminology between traditional and rapid acquisitions environments within the Army and Marine Corps. Due to the differences in word usage between the services, the ability of ABRAHAM to immediately generalize from the Army to Marine Corp setting is somewhat limited. This shortfall can be addressed through a more tailored database for each service.

MCOTEA also noted the absence of statistical analysis and questioned the sensitivity of and requirement for the Alternatives Analysis scoring mechanism. Again, the authors recommended that MCOTEA analysts employ a commercially available statistical analysis package such as SPSS, S-Plus, or SAS until the feature can be implemented in ABRAHAM.

B. CONCLUSION

In summary, ABRAHAM was developed to address the needs of the Rapid Equipping Force's need for a Human System Integration evaluation method. The creation of this Microsoft Access database application was initiated to assist in quickly assessing and fielding new products for Combatant Commanders conducting operations in the rapidly changing and increasingly complex Global War on Terrorism.

ABRAHAM is capable of generating tailored surveys to evaluate REF equipment by prompting the analyst to classify the new system and by applying it to equipment categories within the tool. Based on this classification, ABRAHAM selects applicable questions from its question base and generates a survey for either Alternatives Analysis or Product Evaluation. In the current iteration of ABRAHAM, Alternatives Analysis survey responses are evaluated to identify HSI areas of high risk to equipment operators, maintainers and supporters.

ABRAHAM was showcased in three Department of Defense settings, the Department of Defense Human Factors Engineering Technical Advisory Group, the Army's Rapid Equipping Force, and the United States Marine Corps' Operational Test and Evaluation Activity. During each demonstration, a complete walkthrough of ABRAHAM was conducted and feedback from stakeholders and subject matter experts was requested. In each instance, the authors received positive feedback and multiple requests for immediate implementation.

The overall concept and content of ABRAHAM appears to fill a gap in the current library of HSI tools. Based on the feedback provided during the product demonstrations, it has been determined that there is sufficient interest to further develop this tool both the traditional and rapid acquisition processes. Although the limitations of the current form of ABRAHAM prevent the implementation of critical analysis features, future iterations can easily build upon the foundation and effectively address the concerns identified at each product demonstration.

The next iteration of ABRAHAM should focus on refining the current implementation of the tool in Microsoft Access. Specifically, the tool should be modified to allow for the Product Evaluation Survey to be broken out by surveys specifically

designed for operators, maintainers and supervisors. Additionally, equipment categories within the tool should be modified to meet the equipment fielded by the REF and MCOTEA. Finally, testing of ABRAHAM in a networked environment should be conducted to determine the stability of the tool in a limited multi-user environment. These improvements to ABRAHAM can be implemented immediately in Microsoft Access with little or no development costs.

If funding is provided for further development of ABRAHAM then the following improvements should be considered. First, Microsoft Access provides a limited multi-user environment, but the program can become unstable and unreliable as the database file size and number of users increase. Although Microsoft advertises that Access can support up to 255 users, it is best suited for small single user desktop applications. At best, Microsoft Access is capable of reliably accommodating approximately 10 users with diminishing stability as the database's file size increases. Therefore, it is recommended that ABRAHAM be redesigned for use in a true multi-user database environment such as Oracle, Microsoft SQL, MySQL, FoxPro, or Sybase.

Use of one of these programs will likely require professional programmers who should be capable of addressing the challenges that limited the current Access implementation of ABRAHAM. Most importantly, the programmers must be able to identify a method to store survey results in order to allow for automatic statistical analysis. Another important issue that programmers will need to address in a multi-user environment is providing an ability to identify and consolidate duplicate question entries to keep ABRAHAM streamlined and manageable.

In addition to the programming changes to ABRAHAM, further research should be conducted to determine the most effective method for communicating "HSI-worthiness" in the Alternatives Analysis report. Future work on the tool should also focus on determining if limiting the number of questions is warranted and if so then establishing a methodology for selecting the best questions for each survey. Clearly, this work should be completed before investing in professional programmers to convert the tool.

In order to grow the database of questions within ABRAHAM, a class project should be implemented in a course such as, OA3402, Research Methods for Performance Assessment, that requires each student to develop five or ten Likert scale survey questions that are based on established guidelines within each of the domains of HSI as well as in the areas of reliability, usability, and lethality. This class project can be assigned as homework that supports chapters addressing survey methods. The assignment would not interfere with classroom instruction. The strength of ABRAHAM is based on the quality of questions in the database, and leveraging the knowledge and experience of the Naval Postgraduate School student body can only improve the product.

There are two areas for future thesis work on ABRAHAM. The first thesis opportunity involves evolving ABRAHAM from an application that is primarily geared towards the Army's Rapid Equipping Force to a tool that addresses both rapid and traditional acquisitions in the joint service environment. The second thesis opportunity involves developing recommendations for further analysis for each question in the database.

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APPENDIX A. DATABASE QUESTIONS

DOCTRINE

Does the use of the item improve the speed of the current battle drill?

much worse the same slightly better much better

How many missions have you taken the item on?

In what way did you employ the item during training or at home station?

How do you plan on using the item when you deploy?

Did the employment of this system alter your standard TTPs?

Did the employment of the item alter your standard TTPs for room entering/clearing (or anything else)?

How useful is the Concept of Operations (CONOPS) and Tactics, Techniques, and Procedures (TTP) information provided with the system?

completely somewhat neutral somewhat completely
inadequate inadequate adequate adequate

How many times (missions) have you used this system?

Does the system require new doctrine?

Yes No

The system significantly enhanced your mission success.

strongly disagree neutral agree strongly agree
disagree

Did this system meet your unit requirements?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Other than for the system description, describe any other uses you found for using any of the components of this system:

If no relevant procedures are in place, to what extent would developed and implemented procedures provide either a complete or partial solution to the issue?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Is there a valid need for your organization to have/use this system?

No	Yes
----	-----

Explain generally where (AOR), when (dates used), by who (unit type(s)), and how (CONOPS or TTPs) the system was used.

In what type of area was the system employed? (Open Area, FOB, Urban)

To what extent did the system meet the unit's requirement?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Describe the extent to which the unit needs this system.

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Environment, Safety and Occupational Health

What extreme weather, to include winds/sand storms, was system operated in?

What were the typical weather conditions?

How many times have you either had to activate this system yourself or it activated itself, because of a vehicle fire

Did you have any issues with riding in the vehicle without damaging the system?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

At what type of location did you employ the system?

Do you have any issues with the your ability to secure yourself while wearing the system?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with ingress/egress through ramp/ramp doors (trips, snags, catches)

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

To what extent does the system shield the user from radiation when transmitting?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

What was the approximate average temperature (in degrees Fahrenheit)

FACILITIES

To what extent is the leadership receptive to the user of the new system?

To no extent	To a small extent	To a moderated extent	To a great extent	To a very great extent
-----------------	----------------------	-----------------------------	----------------------	---------------------------

Specify the forward operating base where the barrier system is used?

To what extent does inadequate infrastructure impact the issue?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

Will the system require added special facilities for storage?

Yes	No
-----	----

HABITABILITY

Rate the ease of putting on and taking off the shirt:

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Rate the comfort of the shirt:

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

What is the time of day (hours) when you typically wear this shirt

How many hours do you typically wear this shirt when you wear it?

How many times have you worn this shirt?

Rate the comfort

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Rate the laundering ability of the shirt

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Do you feel comfortable and confident using this product?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Does the system prevent you from fitting inside the vehicle when wearing?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Did you have any issues with comfort while riding in a vehicle with the with the system donned?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

HUMAN FACTORS ENGINEERING

Rate the effectiveness of the weapon adaptor and suppressor mounting mechanism

Very ineffective	Ineffective	Neither ineffective nor effective	Effective	Very effective
---------------------	-------------	---	-----------	-------------------

What components need to be improved and how?

Rate the durability of the mounting system

Very ineffective	Ineffective	Neither ineffective nor effective	Effective	Very effective
---------------------	-------------	---	-----------	-------------------

Rate the ruggedness of the cables

Very ineffective	Ineffective	Neither ineffective nor effective	Effective	Very effective
---------------------	-------------	---	-----------	-------------------

Can the font size be adjust in a reasonable amount of time?

No

Yes

Can the font size be adjusted?

No

Yes

To what extent is the font size of the system legible during operations conditions?

To no
extent

To a small
extent

To a
moderate
extent

To a great
extent

To a very
great extent

Rate the reliability of running this item off of the vehicle battery

completely
unreliable,
prevents
from doing
your jo

unreliable,
hard to do
my job

noticeable
issue,
affects my
job

small issues
but easy to
live with

no issues

What components should be substituted for using other similar types of equipment (include specific suggestions for substitution)?

To what extent does the system require added coordination between systems?

To no
extent

To a small
extent

To a
moderate
extent

To a great
extent

To a very
great extent

Rate the ease of installing the system

Very
difficult

Difficult

Neither
difficult nor
easy

Easy

Very easy

Approximately how many rounds did you shoot through the suppressor?

Did this system ever become inoperable or ineffective?

Always

Most of the
time

Half of the
time

Occasionall

Never

Did this system interfere with the operation of the weapon to which it was mounted?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Is the system checklist easy to understand?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Does the system clearly identify errors?

No	Yes
----	-----

Are there multiple methods of input for users?

No	Yes
----	-----

Were the cables easy to manage and maintain?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Were there any problems with the laptop?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Was battery charger (system/laptop) an issue with extreme hot/cold conditions?

Yes	No
-----	----

Is the system design suitable for the battle field?

No	Yes
----	-----

On average, how long did the filters last between cleanings?

Rate the ease of changing the batteries

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Rate the ease of putting the item on

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

On average, how long did the batteries last?

Can the backlight of the system be adjusted?

No	Yes
----	-----

Were there any interoperability issues?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Rate the maintainability of the system (easily cleaned, fixed, etc.)

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Rate the reliability of the system (daily wear and tear, did it work consistently?):

Very ineffective	Ineffective	Neither effective nor	Effective	Very effective
---------------------	-------------	-----------------------------	-----------	-------------------

Rate the ease of uninstalling the equipment

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

What components need to be eliminated and why?

Rate the ease of operating the system

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
----------------	-----------	----------------------------	------	-----------

Rate the ease assembling

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
----------------	-----------	----------------------------	------	-----------

If this system is fielded, would you use it/wear it?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Describe your experience with the this system (how many times have you used it, during what types of missions, at what time of day/night)?

Did this system meet your mission needs?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Did this system significantly enhance your mission success?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Rate the ease of using this system?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
----------------	-----------	----------------------------	------	-----------

Does the system increase your Situational Awareness?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

At what range did it perform to, in meters?

Are you able to determine that all circuits, adjacent circuits, charged capacitors, or equipment to be repaired are, in fact, de-energized?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

What components need to be added?

How many times did you clean the filters?

Rate the ease/difficulty of the systems ability to create and send messages

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

To what extent was the antenna effective in receiving signals?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Is the software provided adequate for the mission?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Rate the clarity of the text, symbols and icons of the software?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Rate the size of the text?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Rate the size of the symbols?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Were the symbols distinguishable and easy to interpret?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Was the lay of the screen

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Do you have any problems with using the buttons by feel and not sight?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Navigating throughout the program was

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Do you have any issues with mounting/dismounting subsystems of the system?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Rate the ease/difficulty of the systems ability to use map zooming and panning

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

Rate the ease/difficulty of the systems ability to switch between maps

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

Rate the ease/difficulty of the systems ability to backtrack and fix identified errors

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

Rate the ease/difficulty of monitoring the systems status (battery life, signals strength)

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

Rate the ease/difficulty of the system's ability to be configured to operate with other systems.

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

Rate the ease/difficulty of performing maintenance on the system

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

Rate the ease/difficulty of troubleshooting the system

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

The menu item across the were

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Does the system prevent your range of motion?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with the ability to check and change your batteries?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with the weight of this system?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Does this system change the way you wear your gear?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with your ability to wear/ use this system with existing gear?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues the headset comfort after extended wear?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with compatibility of the helmet?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with understanding radio comms?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Does the system prevent you from mounting and dismounting the exterior of a vehicle?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues manipulating the system's buttons with/without gloves and in all weather?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

The software feedback helps to prevent or identify operator errors

completely disagree	somewhat disagree	neutral	somewhat agree	completely agree
------------------------	----------------------	---------	-------------------	---------------------

Does the system prevent you from assuming the correct firing position?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Does the system prevent you from firing around corner/out of windows?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Does the system prevent you from performing individual movements (crawls, climbs)?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Does the system prevent you from clearing rooms while wearing?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Does the system prevent your ability to move with stealth, move quietly, move quickly?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with donning the system?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issue with doffing the systems?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Do you have any issues with the sensitivity of the mouse?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

What effect will battery failure have on the system?

Catastrophic	Major	Moderate	Minor	None
--------------	-------	----------	-------	------

How does the system compare to your normal equipment with respect to your units lethality?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

Compared to your normal equipment, the amount of time it takes to receive reports from your units members?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

Compared to your normal equipment, the amount of time it takes to process reports from your units members?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

Compared to your normal equipment, the amount of time it takes to pass reports from your units members?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

Compared to your normal equipment, what is the impact the system had on the accuracy of the reports processed?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

Compared to your normal equipment, what is the impact the system had on the accuracy of the reports received?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

Compared to your normal equipment, what is the impact the system had on the accuracy of the reports passed on?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

Rate the ease/difficulty to integrate the system with existing systems

impossible	fairly difficult	neutral	fairly easy	no problems at all
------------	---------------------	---------	-------------	-----------------------

How difficult was it to learn to put on the system?

very difficult	moderately difficult	neutral	moderately easy	very easy
-------------------	-------------------------	---------	--------------------	-----------

How does the system compare to your normal equipment with respect to your ability to your ability to request and adjust fire from a joint source?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

To what extent should users be restricted from system use due to physical factors?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent does a fully extended antenna give away system position?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

How many times did you change the batteries?

To what extent was the antenna effective in transmitting signals?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Was GPS reception steady or intermittent?

Intermittent

Steady

To what extent does software glitches require system reset?

To no
extent

To a small
extent

To a
moderate
extent

To a great
extent

To a very
great extent

To what extent does the system require a backlight to make screen visible?

To no
extent

To a small
extent

To a
moderate
extent

To a great
extent

To a very
great extent

How difficult was it to learn to assemble the system?

very
difficult

moderately
difficult

neutral

moderately
easy

very easy

The system improves integration of other systems

strongly
disagree

disagree

neutral

agree

strongly
agree

To what extent does the system require daylight conditions?

To no
extent

To a small
extent

To a
moderate
extent

To a great
extent

To a very
great extent

The use of the system increased understanding of the mission

strongly
disagree

disagree

neutral

agree

strongly
agree

Compared to normal equipment the system improves the units overall force effectiveness

strongly
disagree

disagree

neutral

agree

strongly
agree

Compared to normal equipment the system improves mobility

strongly
disagree

disagree

neutral

agree

strongly
agree

Compared to normal equipment, the system improves the mission pace

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The system helps the unit perform its mission better

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The hindered the units performance

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

How does the system compare to your normal equipment with respect to your ability to coordinate fires and movement with adjacent units?

much worse	worse	the same	slightly better	much better
---------------	-------	----------	--------------------	-------------

The system improves accuracy of target location for indirect fire

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

How does the system compare to your normal equipment with respect to your ability to direct the fires and movement of subordinates?

much worse	worse	the same	slightly better	much better
---------------	-------	----------	--------------------	-------------

The use of the system improves communication between members

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The use of the system improves communication between units

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The system decreases the length of time it takes to receive complete orders with overlays

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The system decreases the length of time it takes to understand complete orders with overlays

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Compared to your normal equipment, what is the impact of the new system on the execution of leader tasks?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

How does the system compare to your normal equipment with respect to your ability to direct employment of smoke?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

How does the system compare to your normal equipment with respect to your ability to your ability to conduct engagements with precision munitions?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

The system is intuitively designed

completely disagree	somewhat disagree	neutral	somewhat agree	completely agree
------------------------	----------------------	---------	-------------------	---------------------

The system reduced length of time required to call for indirect fire

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Is it easy to send and receive short messages using this product?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Rate the ease of taking the item off

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Is the interface with this product clear and understandable?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Are the characters on the screen easy to read?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
----------------	-----------	----------------------------	------	-----------

Does interacting with this product require a lot of mental effort?

Yes	No
-----	----

Is it easy to assemble, install, and/or setup the product?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
----------------	-----------	----------------------------	------	-----------

Can you regulate, control, and operate the product easily?

No	Yes
----	-----

Is the presentation of system information sufficiently clear and understandable?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
-----------------------	---------------------	---------	-------------------	---------------------

Are the input and text entry methods for this product easy and usable?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
----------------	-----------	----------------------------	------	-----------

Is it easy for you to remember how to perform tasks with this product?

No	Yes
----	-----

Is it easy to use the phone book feature of this product?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
----------------	-----------	----------------------------	------	-----------

Is it easy to correct mistakes such as typos?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Is the backlighting feature for the keyboard and screen helpful?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Are the command names meaningful?

No	Yes
----	-----

Discovering new features is sufficiently easy.

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Is the Web interface sufficiently similar to those of other products you have used?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Did you have access to properly rated electrical components, and protective for the job?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Is it easy to navigate between hierarchical menus, pages, and screen?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

All operations can be carried out in a systematically similar way?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Is it easy to check the last call?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Are exchange and transmission of data between this product and other products easy?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

In general, how would you rate the ease of learning the user interface?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

In general, how would you rate the general flexibility the user interface?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

It is difficult to move around this web site

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Is it easy to learn to operate this product?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Is using this product sufficiently easy?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Is it sufficiently easy to operate keys with one hand?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Is it relatively easy to move from one part of a task to another?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Did the radar function properly?

No	Yes
----	-----

Are the operation of this product simple and uncomplicated?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

This product enables the quick, effective, and economical performance of tasks?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

It is easy to access the information that you need from the product?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The organization of information on the product screen is clear?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Does product have all the functions and capabilities you expect it to have?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Are the color coding and data display compatible with familiar conventions?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Is the documentation and manual for this product sufficiently informative?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Have the user needs regarding this product been sufficiently taken into consideration?

strongly disagree	disagree	neutral	agree	strongly agree
-------------------	----------	---------	-------	----------------

The response time and information display fast enough.

strongly disagree	disagree	neutral	agree	strongly agree
-------------------	----------	---------	-------	----------------

Are the design of the graphic symbols, icons and labels on the icons sufficiently relevant?

completely irrelevant	somewhat irrelevant	neutral	somewhat relevant	completely relevant
-----------------------	---------------------	---------	-------------------	---------------------

Does the product provide index of commands?

No	Yes
----	-----

Does the product provide index of data?

No	Yes
----	-----

Are data items kept short?

No	Yes
----	-----

To what extent are the letter codes for the menu selection designed carefully?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

The commands have distinctive meanings.

strongly disagree	disagree	neutral	agree	strongly agree
-------------------	----------	---------	-------	----------------

Is the HELP information given by this product useful?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
-----------------------	---------------------	---------	-------------------	---------------------

The HOME and MENU buttons sufficiently easy to locate for all operations.

strongly disagree	disagree	neutral	agree	strongly agree
-------------------	----------	---------	-------	----------------

Does carrying this product effect your performance?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

To what extent has the product at some time stopped unexpectedly?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

Is the amount of information displayed on the screen adequate?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Is the way product works overall consistent?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Does the product allow the user to access applications and data with sufficiently few keystrokes?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Is the data display sufficiently consistent?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Does the product support the operation of all the tasks in a way that you find useful?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Is the product reliable, dependable, and trustworthy?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The highlighting on the screen helpful.

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Does the brightness of the screen make the product unusable?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Are the messages aimed at preventing you from making mistakes adequate?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Are the error messages effective in assisting you to fix problems?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Is it easy to take corrective actions once an error has been recognized?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Is feedback on the completion of tasks clear?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Does the product give all the necessary information for you to use it in a proper manner?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent is the bolding of commands or other signals helpful?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent does the HELP function define aspects of the product adequately?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Is the organization of the menus sufficiently logical?

completely illogical	somewhat illogical	neutral	somewhat logical	completely logical
----------------------	--------------------	---------	------------------	--------------------

Does the color of the product make it unusable?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------	-------------------------------	----------------------------------	------------------------------------	-----------

Can you personalize warning signals with this product?

No	Yes
----	-----

Are pictures on the screen of satisfactory quality and size?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
-----------------------	---------------------	---------	-------------------	---------------------

Is the number of colors available adequate?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
-----------------------	---------------------	---------	-------------------	---------------------

Are the components of the product are well-matched or harmonious?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Do you feel excited when using this product?

No	Yes
----	-----

Would you miss this product if you no longer had it?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Are you/would you be happy to have this product?

No

Yes

Is it easy to change the ringer signal?

Very
difficult

Difficult

Neither
difficult nor
easy

Easy

Very easy

Is this product's size convenient for transportation and storage?

To no
extent

To a small
extent

To a
moderate
extent

To a great
extent

To a very
great extent

List the 3 best attributes/features of the system:

How long have you been operating the system?

How long does it take to assemble the system?

How long does it take to disassemble the system?

Rate the normal day-to-day performance of the system.

completely
inadequate

somewhat
inadequate

neutral

somewhat
adequate

completely
adequate

Rate the ability to transmit/receive on uneven or hilly terrain.

completely
inadequate

somewhat
inadequate

neutral

somewhat
adequate

completely
adequate

Did the system interfere with the operation of the weapon to which it was mounted?

prevents
from doing
your job

big issues,
hard to do
my job

noticeable
issue,
affects my
job

small issues
but easy to
live with

no issues

Did the placement of the antenna interfere with the operation of the roof-mounted crew served weapon?

prevents from doing your job	big issues, hard to do my job	noticeable issue, affects my job	small issues but easy to live with	no issues
------------------------------------	-------------------------------------	---	--	-----------

Rate the clarity of the PA speaker?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

List the 3 least liked attributes/features of the system:

Is it easy to check missed calls?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Provide any other recommendations for improving or using this system:

Were there any components that did not perform well?

Were there any components that had reliability problems?

Were there any components that had maintenance problems?

Rate the mounting of the Antenna (able to withstand high winds/bursts of speed)?

completely inadequate	somewhat inadequate	neutral	somewhat adequate	completely adequate
--------------------------	------------------------	---------	----------------------	------------------------

Are the non-lethal aspects of the kit appropriate? Why?

Was Video interference a factor?

Yes	No
-----	----

On what type of mission was the system employed? (i.e. Counter IED surveillance, FOB surveillance, Detention facility surveillance) Briefly

Is the tool kit issued with the system sufficient? If not, what would you add

No

Yes

How many hours (at a time) do you typically use this system? (Please circle only one)

Rate your visual performance while using the product.

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

Rate your Visual Depth Perception while using the product.

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

Was it the reaction you anticipated?

Rate the Visual Image Clarity while using the product.

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

How did people respond/react to the use of this item?

At what range was this system employed?

Rate the image quality of the photographs?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

Rate the information contained on the photograph?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

Rate the portability of this item (ease of moving)?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

Rate the image quality of the illuminated sign?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

List any of the components that you normally did not use, and specify why you did not use it (them).

Rate your Visual Field of View while using the product.

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

In general, how would you rate the visual design of the user interface?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

What are any recommendations for improving or using the system?

In general, how would you rate the error messages in the user interface?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

In general, how would you rate the task layout/task flow of the user interface?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

In general, how would you rate the layout of the user interface?

completely	somewhat	neutral	somewhat	completely
inadequate	inadequate		adequate	adequate

How long did it take to set up?

Provide any recommendations for improving or using this system:

Soldiers can effectively complete their mission using this equipment.

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

In general, how would you rate the ease of use of the user interface?

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
-------------------	-----------	----------------------------------	------	-----------

Did this system perform as expected?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Overall, I am satisfied with how easy it is to use this system.

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

Specify any problems identified in operating the system.

To what extent did the system perform as expected?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

LEADERSHIP

To what extent do the senior officers understand the scope of the problem?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent does the issue effect CC or JTF's conduct of Joint operations?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

To what extent has senior leadership identified interservice/agency cultural drivers and barriers which hinder issue resolution?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent does command have resources at its disposal to correct the issue?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent has the command properly assessed the level of criticality, threat, urgency, risk, etc. of the operational results as it relates to the issue?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent is the senior leadership aware of the drivers and barriers to resolving the issue within her/his own organization?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent is leadership being trained on effective change management principles?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

MANPOWER

To what extent does the system increase human performance?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Additional personnel are needed to support the maintenance of the system

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
----------------	-------	---------	----------	-------------------

Will the system increase manpower requirements?

Yes	No
-----	----

Additional personnel are needed for the logistical support of the system

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
-------------------	-------	---------	----------	----------------------

The capabilities of the system will result in the elimination of the currently authorized personnel

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The system will required adding personnel with MOSs not currently in the unit

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
-------------------	-------	---------	----------	----------------------

To what extent are total manpower requirements within Unit constraints?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Compared to your normal equipment, what is the impact of the new system on the execution of squad and platoon collective tasks?

much	worse	the same	slightly better	much better
------	-------	----------	--------------------	-------------

MATERIEL

To what extent does the inability or decreased ability to cooperate/coordinate/communicate with external organizations impact the issue?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

To what extent does inadequate or outdated systems and equipment impact the issue?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

Is maintenance support available in theater?

No	Yes
----	-----

What current systems are in the Family-of-Systems where the problem is occurring?

To what extent should the Army investigate further use of this system and similar systems?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

Is online Tech support available?

No	Yes
----	-----

If the system needed parts then were the parts readily available?

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

The capabilities of the system will require the unit to get additional equipment to complete its mission

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
-------------------	-------	---------	----------	----------------------

The capabilities of the system will make some equipment in my unit no longer necessary

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
-------------------	-------	---------	----------	----------------------

To what extent can performance increases be achieved without the development of a new system?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

In your opinion, should the Army investigate further use of this system and similar system? Explain:

No	Yes
----	-----

What functionality would a new system provide that currently does not exist?

If contractor support was requested how long did it take to get the system fixed?

When the item was deadlined did the unit fix the system or was contractor support requested?

Unit	Contractor
------	------------

Was the item ever deadlined? Y N If yes, why and for how long?

Yes

No

Who would be the primary and secondary users of the proposed systems or equipment?

What increases in operational performance are needed to resolve the issue?

NONE

Use space below to write any additional comments about the system.

ORGANIZATION

To what extent does the organization have the funding to address the issue?

To no
extent

To a small
extent

To a
moderate
extent

To a great
extent

To a very
great extent

What duty position were you filling when you used this system?

Normally, what duty position were you filling when using this system?

The capabilities provided by the system required changes in the platoon's organizational structure

Strongly
agree

Agree

Neutral

Disagree

Strongly
Disagree

Personnel

To what extent is the issue impacted by the inability or decreased ability to place qualified and trained personnel in occupational specialties?

To a very
great extent

To a great
extent

To a
moderate
extent

To a small
extent

To no

To what extent do new training programs need to be developed for newly recruited personnel?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

If issue resolution is likely to involve new material, systems, or equipment, are different occupational specialty codes needed to properly staff new systems?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

The system is too complex for most soldiers to master

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
-------------------	-------	---------	----------	----------------------

The system's tasks are the same for all skill levels within each MOS

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

To what extent will the system likely increase human performance?

To no extent	To a small extent	To a moderate extent	To a great extent	To a moderate extent
-----------------	----------------------	----------------------------	----------------------	----------------------------

Survivability

Did the item encounter any IEDs?

Rate the effectiveness of the suppressor flash

Very ineffective	Ineffective	Neither ineffective nor effective	Effective	Very effective
---------------------	-------------	---	-----------	-------------------

The use of the system improves the units ability to locate mines and booby trap

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

At what speed did you encounter the IEDs?

To what extent does the system increase mission performance?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent does the system reduce situational awareness?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent does the system increase your personal protection?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent does the backlight of the system give away position?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

The use of the system improves the units ability to avoid enemy fire

strongly disagree	disagree	neutral	agree	strongly agree
-------------------	----------	---------	-------	----------------

Compared to normal equipment the system improves the unit's survivability

strongly disagree	disagree	neutral	agree	strongly agree
-------------------	----------	---------	-------	----------------

Rate the effectiveness of the suppressor in reducing the acoustic signature of the weapon.

Very ineffective	Ineffective	Neither ineffective nor effective	Effective	Very effective
------------------	-------------	-----------------------------------	-----------	----------------

TRAINING

To what extent can Government and contractor personnel be trained to complete all system-related tasks?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

How effective is the delivery of the training?

Very ineffective	Ineffective	Neither effective nor	Effective	Very effective
------------------	-------------	-----------------------	-----------	----------------

To what extent does current training exist to address the issue?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent is the current issue caused by a complete lack of or inadequate training?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

What training methods and technologies will be used?

To what extent has the personnel flow through the personnel pipeline been evaluated?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Overall, how frequently will sustainment or refresher training be needed?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
------------------------	-------------------	----------------------	-------------------	-------

To what extent have training objectives been specified in detail?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent do affected personnel have access to training?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

To what extent have the training objectives been specified in sufficient detail?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent is computer literacy required?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent does the training address the original 10-Liner Requirement?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

The Training System is designed to improve skillsets in which of the HSI domains?

To what extent is the training given to the troops valid for the task?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

How effectively can the reliability of the training be measured?

Very ineffective	Ineffective	Neither effective nor	Effective	Very effective
---------------------	-------------	-----------------------------	-----------	-------------------

To what extent will the user have an opportunity to practice with the equipment prior to using it in a true operational setting?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent does the training system change personnel requirements?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

What effect does the training have on decreasing manpower requirements?

Very ineffective	Ineffective	Neither effective nor	Effective	Very effective
---------------------	-------------	-----------------------------	-----------	-------------------

Will training be at the individual, crew/team, or unit level?

Adequate training materials or support is available.

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

To what extent have the system's critical tasks been identified for support personnel?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

If it is not possible to simplify the task, to what extent is more training required?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent is training properly funded?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

How effectively will the training system enable soldiers to complete currently assigned duties?

Very ineffective	Ineffective	Neither ineffective nor effective	Effective	Very effective
---------------------	-------------	---	-----------	-------------------

To what extent does lack of proper environment controls impact the issue?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
---------------------------	----------------------	----------------------------	----------------------	-------

To what extent can government and contractor personnel be trained on all system-related tasks within the time allotted?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

How difficult was it to learn to maintain the system?

very difficult	moderately difficult	neutral	moderately easy	very easy
----------------	----------------------	---------	-----------------	-----------

To what extent are training results being measured and monitored?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
--------------	-------------------	----------------------	-------------------	------------------------

Rate the training that you received on this system.

Very ineffective	Ineffective	Neither effective nor	Effective	Very effective
------------------	-------------	-----------------------	-----------	----------------

To what extent is the issue caused by a lack of competency or proficiency on existing systems and equipment?

To a very great extent	To a great extent	To a moderate extent	To a small extent	To no
------------------------	-------------------	----------------------	-------------------	-------

What percentage of the target population is capable of understanding the training required to properly operate the new system?

up to 20%	21% -	41% -	61% -	81% - 100%
-----------	-------	-------	-------	------------

Were the installation procedures accurately portrayed in the Training Support Package?

strongly disagree	disagree	neutral	agree	strongly agree
-------------------	----------	---------	-------	----------------

How difficult was it to learn to remove the system?

very difficult	moderately difficult	neutral	moderately easy	very easy
----------------	----------------------	---------	-----------------	-----------

New arrivals to the unit will be able to use the system with only OJT

strongly disagree	disagree	neutral	agree	strongly agree
----------------------	----------	---------	-------	-------------------

To what extent is the training properly staffed?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent is the command/management supporting and/or enforcing the training effort?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

To what extent have the system's critical tasks been identified for maintainers?

To no extent	To a small extent	To a moderate extent	To a great extent	To a very great extent
-----------------	----------------------	----------------------------	----------------------	---------------------------

How difficult was it to learn to operate the system?

very difficult	moderately difficult	neutral	moderately easy	very easy
-------------------	-------------------------	---------	--------------------	-----------

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APPENDIX B. REF SYSTEM ASSESSMENT FORM

System Assessment Form – System/Item Name: _____ Date: _____

Location: _____ Unit: _____

Rate the following from 1 to 10 (circle your answer).

Terrible Poor Adequate Good Excellent

Performance: Does the system/item perform as expected?

1 2 3 4 5 6 7 8 9 10

Effectiveness: Does the system/item meet requirements?

1 2 3 4 5 6 7 8 9 10

Survivability: Is the system/item adequately built for field use?

1 2 3 4 5 6 7 8 9 10

Training: Are adequate training materials/support available?

1 2 3 4 5 6 7 8 9 10

Reliability: Does the system/item hold up under continual use?

1 2 3 4 5 6 7 8 9 10

Maintainability: Is the system/item easily cleaned & fixed?

1 2 3 4 5 6 7 8 9 10

Supportability: Are parts/procedures/support readily available?

1 2 3 4 5 6 7 8 9 10

Operation: Is the system/item easy to operate?

1 2 3 4 5 6 7 8 9 10

Interoperation: How well does the system operate with other systems, if required?

1 2 3 4 5 6 7 8 9 10

Employment: If this system was fielded, would you use it? Yes No

How would you use it?

PROS: List and explain at least 3 things you like about the system/item.

CONS: List and explain at least 3 things you do not like about the system/item.

Item Improvement: What suggestions can you provide to improve the system/item.

APPENDIX C. ABRAHAM ANALYSIS REPORT

1. The following report is based on a review of the individual HSI domains and the responses to the questions generated by this tool. The goal of this report is to identify the question responses that imply critical, major or moderate risks to acceptable performance of the human and system in the operational environment. This assessment relies upon the honest and forthright responses of the user, and any efforts to address these HSI issues will require that leadership verify the deficiencies exist.
2. The overall score for this piece of equipment is based on your responses to the questions and the importance rating given to each of the questions.
3. The following questions indicate that there may be issues with the system that would cause unnecessary performance decrement that could adversely impact Soldier safety, survivability, and lethality. Specific issues are identified as follows:

CRITICAL ISSUES:

Question:

What percentage of the target population is capable of understanding the training required to properly operate the new system?

Your Response: up to 20%

Question Score: 3 Maximum Possible 15

Additional Comments:

The training is hard to understand. Nobody has scored acceptably on the exit exam.

Major Issues:

Question:

To what extent is the current issue caused by a complete lack of or inadequate training?

Your Response: To a small extent

Question Score: 6 Maximum Possible: 15

Additional Comments:

Question:

Overall, how frequently will sustainment or refresher training be needed?

Your Response: To a great extent

Question Score: 2 Maximum Possible: 10

Additional Comments:

Question:

To what extent can Government and contractor personnel be trained to complete all system-related tasks?

Your Response:

To a small extent

Question Score: 4 Maximum Possible: 10

Additional Comments:

Question:

To what extent have the training objectives been specified in sufficient detail?

Your Response: To a small extent

Question Score: 4 Maximum Possible: 10

Additional Comments:

MODERATE ISSUES:**Question:**

To what extent have training objectives been specified in detail?

Your Response: To a moderate extent

Question Score: 6 Maximum Possible: 10

Additional Comments:

Question:

To what extent will the user have an opportunity to practice with the equipment prior to using it in a true operational setting?

Your Response: To a moderate extent

Question Score: 3 Maximum Possible: 15

Additional Comments:

Overall Score: 28 Out of a maximum of: 85

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